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MATERIALS SELECTOR

1958-59 REFERENCE ISSUE

Materials
in Design Engineering
Formerly Materials & Methods

1958-59
REFERENCE
ISSUE

MATERIALS SELECTOR

This second annual issue of the Materials Selector is similar to but more extensive than last year's issue. It contains 50 new pages of data, including an entirely new section on Joining and Fastening of Materials. The data published last year have been revised, in cooperation with sharp-eyed readers, to reduce or eliminate errors. In addition, the Directory has been expanded by 50%—it covers more categories and lists more suppliers—and has been brought up to date.

Like last year's issue, this Materials Selector consists of two major sections: a Data Section and a Directory Section. Each major section is subdivided to make it as useful as possible. Contents of the entire issue are listed on these two pages; in addition, a more detailed contents page appears at the beginning of most subsections. All subsections, numbered from 1 to 6, are described briefly below and can be readily located by means of the small edge index tabs at the far right.

PAGE

1 Comparisons of Materials . . . 7

Based on specific end service requirements

Tables comparing the important engineering materials with respect to a particular property (e.g., tensile strength). The major part of this section is a series of data sheets in which materials are ranked in descending order for various properties. In most cases, the materials are ranked by their average properties, the approximate range also being given. In some cases the temper, heat treatment or other condition of the material is given, particularly where such conditions markedly affect the value. More details on materials and conditions can be found in Section 2, from which these data were compiled.

PAGE

2 Properties of Materials 29

Typical properties and uses of the important engineering materials. Most of the information is given in a standard tabular form, making comparison easy, and test conditions are summarized where known. A list of helpful bulletins available from suppliers appears at the beginning of each section, and advertisements of suppliers appear at the end of each section.

2a. Irons and Steels . . . . Page 31
2b. Nonferrous Metals . . . Page 83
2c. Plastics and Rubber . . Page 141
2d. Other Nonmetallics . . Page 227
2e. Finishes and Coatings . Page 257

PAGE

3 Forms & Shapes of Materials 293

Data on the common forms (castings, moldings, etc.) of engineering materials. Much of the information is in tabular form. A list of helpful bulletins available from suppliers appears at the beginning of the section, and advertisements of suppliers appear at the end of the section.

4 Joining & Fastening of Materials . . . . . PAGE 371

Data on the joining and fastening methods used for engineering materials. A list of helpful bulletins available from suppliers appears at the beginning of the section, and advertisements of suppliers appear at the end of the section.

DIRECTORY SECTION

The Directory Section, consisting of two parts, contains the names of the leading suppliers of engineering materials and their forms and shapes. A full explanation of the organization and use of the Directory is given on page 408.

PAGE

5 Suppliers of Materials 407

An alphabetical index to the important engineering materials and forms of materials, containing under each heading the names of the leading suppliers.

PAGE

6 Addresses of Suppliers 460

An alphabetical list of the names and addresses of the suppliers of engineering materials and forms mentioned in Section 5.

OTHER FEATURES

	PAGE
How to Use the Selector	2
Index to Data	3
Sources of Data	24
What the Data Mean	29
Reader Inquiry Cards	367, 405, 479
How to Use the Directory	408
Index to Advertisers	403

Suppliers' Literature

	PAGE
IRONS AND STEELS	30
NONFERROUS METALS	82
PLASTICS AND RUBBER	140
OTHER NONMETALLICS	226
FINISHES AND COATINGS	256
FORMS AND SHAPES	292, 366, 369
JOINING AND FASTENING	370

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How to Use the Selector

Naturally, you can use this issue in many different ways, depending upon the nature of your own materials problems. However, this issue is called the Materials Selector because it is designed to help you systematically narrow your choice of materials, parts and finishes to meet a specific problem. Here is a logical procedure:

1. See Section 1 (Comparisons of Materials).
Look up the critical properties and see which materials seem to warrant further investigation.

2. See Index to Data.
Find what pages give information on the materials selected for study.

3. See Section 2 (Properties of Materials).
Look up the pages indicated by the Index. Reduce the number of materials requiring further study by comparing significant properties, available forms and typical uses.

4. See Section 3 (Forms and Shapes of Materials).
Narrow the choice of materials further by comparing the characteristics of competitive forms and shapes.

5. See Section 4 (Joining and Fastening of Materials).
If assembly is required, limit the choice of materials still further by comparing the characteristics of competitive joining materials and processes.

6. See Section 5 (Suppliers of Materials).
Look up still promising materials and forms to obtain the names of suppliers, as well as a good indication of commercial availability.

7. See Section 6 (Addresses of Suppliers).
Look up the names of promising suppliers to obtain their addresses.

8. Obtain detailed information
on properties, availability and cost of materials and fabricated forms by:

a. Writing to suppliers.

b. Consulting the Suppliers' Literature pages in Sections 2, 3 and 4. Note the key numbers of promising bulletins and circle them on the free post card (pp 367, 405 and 479).

c. Consulting the advertisements. Names of advertisers are bold faced throughout the Directory, and the pages on which their advertisements appear are listed following their addresses.

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Index to Data

a

Acetal, 166
Acetate fibers, 238
Acrilan fibers, 239
Acrylics (see also Plastics Parts)
  Adhesives, 386 ff.
  Coatings, 269
  Fibers, 239
  Plastics, 142
  Rubber, 177
Acrylonitrile rubber
  Adhesives, 386 ff.
  Properties, 176
Acrylonitrile-butadiene-styrene copolymers, 162
Adhesives, 386-388
  Joinability of materials, 374
Admiralty metal (see also Brass), 102
Age-hardening stainless steels, 55
Albumin Adhesives, 386 ff.
Alkyds (see also Plastics Parts)
  Adhesives, 386 ff.
  Coatings, 267-269
  Plastics, 143
  Precoatings, 277
Allyls (see also Plastics Parts), 158
Alumina, 231
Aluminum and its alloys
  Adhesive bonded, 386 ff.
  As a cladding or precoating, 272
  As a sprayed coating, 265
  Brazed, 374 ff.
  Cast, 88-91
  Castings, types of, 296 ff.
  Conversion coated, 259
  Chromium electroplated, 260
  Clad and precoated, 272 ff.
  Extruded, 300
  Finishes, mechanical, 266
  Forged, 308 ff.
  Forms, comparison of, 294
  Formability, 303
  Hard coatings and surfaces, comparison of, 258
  Impact extruded, 302
  Joinability, 372
  Machinability, 318
  Mechanically fastened, 389 ff.
  Nickel electroplated, 263
  Porcelain enameled, 270
  Properties, 84-91
  Soldered, 374 ff.
  Spinnability, 319
  Stamped and press formed, 303 ff.
  Tubing, 320-323
  Welded, 378 ff.
Aluminum (cont'd)
  Welding rods and electrodes, 378 ff.
Aluminum brass (see also Brass), 102
Aluminum bronze (see also Bronze), 99
Aluminum silicate
  Fibers, 237
  Glass, 234
Aluminum-silicon brazing alloys, 374 ff.
Amine coatings, 267, 268
Anodic conversion coatings (see also Coatings), 259
Anodized coatings (see also Coatings), 259
Arc welding (see also Welding), 378 ff.
Asbestos fibers, 237
Asphalt adhesives, 386 ff.
Austenitic stainless steels, 55

b

Babbitts
  As a sprayed coating, 265
  Lead-base, 118
  Tin-base, 117
Bast fibers, 240
Bending (see also Press Formed Parts)
  Allowances, 305
  Radii, minimum, 304
Beryllia, 231
Beryllium carbide, 233
Beryllium copper (see also Copper and Its Alloys), 94
Bismuth solders, 374 ff.
Blanked parts (see also Press Formed Parts, 303 ff.
Bolts, 389 ff.
Bone adhesives, 386 ff.
Board, composition, 241
Boron carbide, 232
Borosilicate glass, 235
Brass (see also Copper and Its Alloys)
  Adhesive bonded, 386 ff.
  Aluminum brass, 103
  As a cladding or precoating, 272
  As a sprayed coating, 265
  Brazed, 374 ff.
  Castings, types of, 296
  Clad and precoated, 272 ff.
  Extruded, 300
  Formability, 303 ff.
  Forged, 308 ff.
Brass (cont'd)
  Forms, comparison of, 294
  Hard coatings and surfaces, comparison of, 258
  Impact extruded, 302
  Joinability, 372
  Machinability, 318
  Mechanically fastened, 389 ff.
  Plain, 94
  Powder metal parts, 316
  Properties, 94 ff.
  Red, leaded, cast, 98
  Roll formed, 306
  Semi-red, leaded, cast, 98
  Soldered, 374 ff.
  Spinnability, 319
  Stamped and press formed, 303 ff.
  Tin brass, 102
  Tubing, 320-323
  Welded, 378 ff.
  Welding rods and electrodes, 378 ff.
Brazed parts, compared with other forms, 294
Brazing
  Alloys, 374-377
  Joinability of materials, 372
Bronze (see also Copper and Its Alloys)
  Adhesive bonded, 386 ff.
  As a cladding or precoating, 272
  As a sprayed coating, 265
  Brazed, 374 ff.
  Castings, types of, 296 ff.
  Clad and precoated, 272 ff.
  Extruded, 300
  Forged, 308
  Forms, comparison of, 294
  Hard coatings and surfaces, comparison of, 258
  Joinability, 372
  Mechanically fastened, 389 ff.
  Phosphor, 100
  Properties, 99
  Soldered, 374 ff.
  Stamped and press formed, 303 ff.
  Welded, 378 ff.
  Welding rods and electrodes, 378 ff.
Butadiene-acrylonitrile rubber
  Adhesives, 386 ff.
  Properties, 176
Butadiene-styrene rubber
  Adhesives, 386 ff.
  Properties, 176
Butyl rubber, 176
Butyrate coating, 269

c

Cadmium
  As an electroplate, 264
  Conversion coated, 259
  Solders, 374 ff.
Calcia, 231
Calendered sheet, 313
Carbides, 232
Carbon, 236
Carbonitrided surfaces, 258
Carburized surfaces, 258
Cartridge brass (see also Brass), 95
Casein adhesives, 386 ff.
Castings (see also specific material)
  Compared with other forms, 294
  Metal, 296 ff.
  Plastics, 312
Cellulose fibers, 238
Cellulosics (see also Plastics Parts)
  Acetate, 144
  Acetate butyrate, 145
  Adhesives, 386 ff.
  Cellular, 181
  Ethyl cellulose, 146
  Fibers, 238
  Films, 168
  Lacquer precoated metal, 277
  Nitrate, 146
  Propionate, 145
  Vulcanized fibre
    Design practice, 315
    Properties, 170 ff.
Ceramics
  Adhesive bonded, 386 ff.
  Electrical, 228
  Fibers, 237
  Joinability, 372
  Mechanical, 228
  Mechanically fastened, 389 ff.
  Refractory, 231
Cermets, 231, 232
Chemical conversion coatings, 259
Chlorinated rubber coatings, 269
Chloroprene rubber, 176
Chromate conversion coatings, 259
Chromium
  As a cladding or precoating, 272 ff.
  As an electroplate, 260
  Hard coatings and surfaces, comparison of, 258
Chromized surfaces, 258
Clad and precoated metals, 272-277

Closed die forgings, 308-310
Coatings
  Conversion, 259
  Electroplates
    Cadmium, 264
    Chromium, 260
    Nickel, 262
    Zinc, 264
  Hard, comparison of, 258
  Organic, 267
  Porcelain enamel, 270
  Precoated metals, 272-277
  Sprayed metal, 264
Cobalt and its alloys, 92
Coefficient of thermal expansion, 10
Coined parts (see also Press Formed Parts), 316
Cold headed parts (see also Forgings), 308
Cold molded plastics parts (see also Molded Parts), 311
Columbium, 93
Columbium carbide, 233
Commercial bronze (see also Brass), 94
Composition board, 241
Compression molded plastics parts (see also Molded Parts, Plastics), 311
Continuous cast parts, 294
Conversion coatings, 259
Copper and its alloys (see also particular alloy)
  Adhesive bonded, 386 ff.
  As a cladding or precoating, 272
  Brazed, 374 ff.
  Cast, 96-99
  Castings, types of, 296 ff.
  Chromium electroplated, 260
  Clad and precoated, 272 ff.
  Conversion coated, 259
  Copper-base brazing alloys, 374 ff.
  Extruded, 300
  Finishes, mechanical, 266
  Forged, 308
  Formability, 303 ff.
  Forms, comparison of, 294
  Hard coatings and surfaces, comparison of, 258
  Impact extruded, 302
  Joinability, 372
  Machinability, 318
  Mechanically fastened, 389 ff.
  Nickel electroplated, 263
  Powder metal parts, 316
  Properties, 94-102
  Roll formed, 306
  Soldered, 374 ff.
  Spinnability, 319
  Stamped and press formed, 303 ff.
  Tubing, 320-323
  Welded, 378 ff.
  Welding rods and electrodes, 378 ff.
Cordierite, 228
Cotton fibers, 240
Creep strength, 20
Cuprammonium fibers, 238
Cyanided surfaces, 258

d

Dacron fibers, 238
Density (see Specific Gravity)
Diallyl phthalate (see also Plastics Parts), 147
Die castings (see also Castings), 296 ff.
Die formed parts (see also Press Formed Parts), 303 ff.
Dihydroperfluorobutyl acrylate rubber, 143
Diisocyanate-polyester rubber, 177
  Flexible foam, 179
  Foamed-in-place, 180
Drawn shapes (see also Press Formed Parts), 303 ff.
  Hold-down pressures, minimum, 306
  Reductions, maximum, 306
  Single draw limitations, 307
  Tolerances, 306
Drop forgings (see also Forgings), 308-310
Drop hammer formed parts (see also Press Formed Parts), 307
Duranickel (see also Nickel and Its Alloys), 110
Dynel fibers, 239

e

Elastomers (see also particular elastomer)
  Adhesives, 386 ff.
  Adhesive bonded, 386 ff.
  Joinability, 372
  Mechanically fastened, 389 ff.
Electrical resistivity, 12
Electrical ceramics, 229
Electrochemical conversion coatings, 258
Electrodes, welding, 378 ff.
Electroformed parts, 294
Electroplates
  As a precoating, 272 ff.
  Cadmium, 264
  Chromium 260
  Compared with other hard coatings, 258
  Nickel, 262
  Zinc, 264
Elongation, 16
Epoxies (see also Plastics Parts)
  Adhesives, 386 ff.
  Coatings, 268
  Foamed-in-place, 580
  Plastics, 148
  Prefoamed, 581
Ethyl cellulose (see also Plastics Parts)
  Films, 168
  Plastics, 146
Extrusions
  Compared with other forms, 294
  Impact, 302
  Metal, 300
  Plastics, 312
  Stepped, 301

f

Fabrics, joinability of, 372
Fabricated sheet metal parts, 303-307
Fasteners, mechanical, 389-393
  Joinability of materials, 374
Felts, mechanical, 242-243
  Adhesive bonded, 386 ff.
  Mechanically fastened, 389 ff.
Ferritic stainless steels, 54
Fibers
  Mineral, 237
  Natural, 240
  Synthetic, 238
Fibre, vulcanized (see Vulcanized Fibre)
Films, plastics, 167-169
Filter Felts, 242
Fish adhesives, 386 ff.
Flame hardened surfaces, 258
Flax fibers, 240
Flexible die-formed parts (see also Press Formed Parts), 307
Flexible foams, 179
Flexible punch-formed parts (see also Press Formed Parts), 307
Fluorinated acrylic rubber, 177
Fluorocarbons (see also Plastics Parts)
  Coatings, 269
  Fibers, 238
  Plastics, 149
Fluxes
  Brazing, 374 ff.
  Soldering, 374
  Welding, 378 ff.
Foams
  Adhesive bonded, 386 ff.
  Flexible, 179
  Foamed-in-place, 180
  Mechanically fastened, 389 ff.
  Prefoamed, 181
Forgings, 308-310
  Compared with other forms, 294
Formability of metals, 303 ff.
Forsterite, 228
Fortisan 36 fibers, 238

g

Gas welding (see also Welding), 378 ff.
Gilding (see also Brass), 34
Glass
  Adhesive bonded, 386 ff.
  Fibers, 237
  Industrial, 234
  Joinability, 372
  Mechanically fastened, 389 ff.
Glycerin adhesives, 386 ff.
Gold
  As a cladding or precoating, 272 ff.
  Hard coatings and surfaces, comparison of, 258
  Properties, 114
Graphite, 236
Grid metal (see also Lead and Its Alloys), 105
GR-S rubber
  Adhesives, 386 ff.
  Properties, 176

h

Hafnium, 103
Hard coatings and surfaces (see also type or material), 258
Hardboard, 241
Hardness, 18
Haynes Alloy, 92
Haynes Stellite, 92
Heat resistant alloys, 62-64
Hemp fibers, 240
Hennequin fibers, 240
Hide adhesives, 386 ff.
High temperature strength
  Creep, 20
  Stress-rupture, 21
High-leaded tin bronze, cast, 97
Horsehair fibers, 240
Hot dipped precoated metals, 272 ff.
Hydopress formed parts, 307

i

Impact extrusions, 302
  Compared with other forms, 294
Inconel (see also Nickel and Its Alloys), 111
Induction hardened surfaces, 258
Injection molded plastics parts (see also Molded Parts, Plastics), 311
Inorganic adhesives, 386 ff.
Inserts, 389 ff.
Investment castings (see also Castings), 296 ff.
Iridium, 115
Iron
  Adhesive bonded, 386 ff.
  Brazed, 374 ff.
  Cadmium electroplated, 264
  Castings, types of, 296 ff.
  Chromium electroplated, 260
  Clad and precoated, 272 ff.
  Conversion coated, 259
  Ductile, 34
  Forged, 308
  Forms, comparison of, 294
  Gray
    Castings, types of, 296 ff.
    Properties, 32
  Hard coatings and surfaces, comparison of, 258
  Ingot, 37
  Joinability, 372
  Machinability, 318
  Malleable
    Properties, 36
    Sand cast, 296 ff.
  Mechanically fastened, 389 ff.
  Nickel electroplated, 263
  Nodular, 34
  Porcelain enameled, 270
  Powder metal parts, 316
  Soldered, 374 ff.
  Welded, 378 ff.
  Welding rods and electrodes, 378 ff.
  White, sand cast, 296 ff.
  Wrought, 37
  Zinc electroplated, 264
Isobutylene isoprene rubber, 176

j

Joining
  Adhesives, 386-388
  Brazing and soldering alloys, 374-377
  Joinability of materials, 372
  Mechanical fasteners, 389-393
  Welding rods and electrodes, 378-385
Jute fibers, 240

l

Laminates
  High pressure (see also Vulcanized Fibre)
    Design practice, 314 ff.
    Properties, 170-175
  Low pressure, 315
  Reinforced, 314
Latex foam (see also Foams), 179
Lead and its alloys (see also Particular Alloy)
  Adhesive bonded, 386 ff.
  As a cladding or precoating, 272 ff.
  As a sprayed coating, 265
  Castings, types of, 296 ff.
  Extruded, 300
  Impact extruded, 302
  Joinability, 372
  Mechanically fastened, 389 ff.
  Properties, 105
  Punch penetration, 303

Lead (cont'd)
Soldered, 374 ff.
Spinnability, 319
Welded, 378 ff.
Welding rods and electrodes, 378 ff.
Lead silicate glass, 234
Lead-base materials
Babbitts, 117
Solders, 374 ff.
Leaded tin bronze, cast, 96
Leather
Adhesive bonded, 386 ff.
Joinability, 372
Mechanically fastened, 389 ff.
Locking fasteners, 389 ff.
Low brass (see also Brass), 95

m

Machinability, 318
Magnesia, 231
Magnesium alloys
Adhesive bonded, 386 ff.
Brazed, 374 ff.
Brazing alloys, 374 ff.
Cast, 107, 109
Castings, types of, 296 ff.
Chromium electroplated, 260
Conversion coated, 259
Extruded, 300
Forged, 308
Formability, 303 ff.
Forms, comparison of, 294
Hard coatings and surfaces, comparison of, 258
Impact extruded, 302
Joinability, 372
Machinability, 318
Mechanically fastened, 389 ff.
Properties, 106-109
Soldered, 374 ff.
Spinnability, 319
Stamped and press formed, 303 ff.
Tubing, 320-323
Welded, 378 ff.
Welding rods and electrodes, 378 ff.
Manganese bronze (see also Brass), 102
Manila fibers, 240
Marform process, 307
Martensitic stainless steels, 52
Maximum service temperatures of plastics and rubber, 11
Mechanical fasteners, 389-393
Joinability of materials, 374
Mechanical felts, 242-243
Mechanical tubing (see Tubing, Mechanical)
Melamines (see also Plastics Parts)
Adhesives, 386 ff.
Coatings, 268
Plastics, 150
Melting points of metals and ceramics, 11
Metal coatings, sprayed
Compared with other hard coatings, 258
Properties, 265
Metal powder parts, 316
Compared with other forms, 294
Metals (see also particular metal)
Adhesive bonded, 386 ff.
Brazed, 374 ff.
Formability, 303 ff.
Forms, comparison of, 294
Joinability, 372
Mechanically fastened, 389 ff.
Soldered, 374 ff.
Metals (cont'd)
Welded, 378 ff.
Mineral fibers, 237
Modified polystyrenes (see also Plastics Parts), 162, 181
Modulus of elasticity in tension, 13
Molded parts, plastics (see also particular material)
Cold, 311
Compression, 311
Injection, 311
Reinforced laminates, 313 ff.
Thermoplastic sheet, 313 ff.
Transfer, 311
Molybdenum
As a sprayed coating, 265
Brazed, 374 ff.
Clad and precoated, 272 ff.
Properties, 93
Spinnability, 319
Monel (see also Nickel and Its Alloys), 111
Muntz metal (see also Brass), 95

n

Natural adhesives, 386 ff.
Natural fibers, 240
Natural rubber, 176
Naval brass (see also Brass), 102
Neoprene rubber
Adhesives, 386 ff.
Properties, 176
Nickel and its alloys (see also particular alloy)
Adhesive bonded, 386 ff.
As a cadding or precoating, 272 ff.
As an electroplate, 262
As a sprayed coating, 265
Brazed, 374 ff.
Brazing alloys, 374 ff.
Cast, 112
Chromium electroplated, 260
Clad and precoated, 272 ff.
Extruded, 300
Forged, 308
Forms, comparison of, 294
Hard coatings and surfaces, comparison of, 258
Joinability, 372
Low expansion alloys, 113
Machinability, 318
Mechanically fastened, 389 ff.
Powder metal parts, 316
Properties, 110-113
Soldered, 374 ff.
Spinnability, 319
Stamped and press formed, 303 ff.
Tubing, 320-323
Welded, 378 ff.
Welding rods and electrodes, 378 ff.
Nickel silver (see also Copper and Its Alloys), 101
Nitrided surfaces, 258
Nitrile rubber, 176
Nitrocellulose coating, 269
Nuts, 389 ff.
Nylons (see polyamides)

o

Oleoresin adhesives, 386 ff.
Open die forgings, 308
Organic coatings
Precoated metals, 272 ff.
Properties, 267
Orlon fibers, 239
Osmium, 115
Oxide conversion coatings, 259
Oxyacetylene welding (see also welding), 378 ff.

p

Painted coatings (see Organic Coatings)
Palladium
As a cladding or precoating, 272 ff.
Particle board, 241
Properties, 114
Permanent mold castings (see also Castings), 296 ff.
Pewter (see also Tin and Its Alloys)
Nickel electroplated, 263
Properties, 116
Spinnability, 319
Phenolics (see also Plastics Parts)
Adhesives, 386 ff.
Cast, 157
Coatings, 267, 268
Foam, 180
Plastics, 154-157
Phosphate conversion coatings, 259
Phosphor bronze (see also Bronze), 100
Pierced parts (see also Press Formed Parts), 303 ff.
Plaster mold castings (see also Castings), 296
Plastics parts
Adhesive bonded, 386 ff.
Castings, 312
Extrusions, 312
Films, 167-169
Foams, 179-181
High pressure laminates
Design practice, 314 ff.
Properties, 170-175
Joinability, 372
Mechanically fastened, 389 ff.
Molded, 311
Reinforced laminates, 313 ff.
Thermoplastic sheet molded, 313 ff.
Welded, 372
Plate glass, 234
Platinum
As a cladding or precoating, 272 ff.
Properties, 114
Polyamides (see also Plastics Parts)
Fibers, 238
Plastics, 152
Polycarbonate, 166
Polyesters (see also Plastics Parts)
Fibers, 238
Films, 168
Plastics, 158
Polyethylene (see also Plastics Parts)
Cellular, 179
Fibers, 239
Films, 167
Plastics, 159
Polymethylstyrene (see also Plastics Parts), 161
Polypropylene, 166
Polysiloxanes (see Silicone)
Polystyrenes (see also Plastics Parts)
Films, 168
Foamed-in-place, 180
Modified, 162, 181
Prefoamed, 181
Properties, 161-162
Polysulfide rubber, 177
Polysulfide-epoxy (see also Plastics Parts), 148
Polytetrafluoroethylene (see also Plastics Parts)
Coatings, 269
Fibers, 238
Films, 168
Plastics, 149
Polytrifluorochloroethylene (see also Plastics Parts)
Coatings, 269
Films, 168
Plastics, 149
Polyvinylidene chloride (see Polyvinyls)
Polyvinyls
Adhesives, 386 ff.
Alcohols
Films, 167
Plastics, 165
Butyral, 165
Chloride
Films, 167
Plastics, 164
Chloride, acetate, 164
Coatings, 269
Copolymers, 164
Formal, 165
Open-cell foam, 179
Precoatings, 272 ff.
Vinylidene chloride
Fibers, 239
Films, 167
Plastics, 164
Porcelain enamels, 270
Powder metallurgy parts (see Metal Powder Parts)
Precipitation-hardening stainless steels, 55
Precision sand castings (see also Castings), 296 ff.
Press forgings (see also Forgings), 308-310
Press formed parts, 303 ff.
Compared with other forms, 294 ff.
Pressed die-formed parts (see also Press Formed Parts), 306
Protein fibers, 239
Punched parts (see also Press Formed Parts), 307
Penetration through metal, 303
Radii, minimum, 306

r

Radiation effects, 22
Ramie fibers, 240
Rayon fibers, 238
Red brass (see also Brass), 95, 98
Refractories, 231
Resistance welding (see also Welding), 378 ff.
Resistivity, electrical, 12
Resorcinal adhesives, 386 ff.
Rhodium
As an electroplate, 258
Properties, 115
Rivets, 389 ff.
Rods, welding, 378 ff.
Roll felts, 242
Roll formed shapes, 306
Compared with other forms, 294
Rosin adhesives, 386 ff.
Rubber
Adhesive-bonded, 386 ff.
Adhesives, 386 ff.
Brazed, 374 ff.
Chlorinated coating, 269
Compounds, 176
Films, 168
Foam, 179

Rubber (cont'd)
Hard, 178
Joinability, 372
Mechanically fastened, 389 ff.
Rubber pad-formed parts (see also Press Formed Parts), 307
Ruthenium, 115

s

Sand castings (see also Castings), 296
Saran fibers, 239
Screw machine parts, 318
Compared with other forms, 294
Screws, 389 ff.
Seamless tubing (see also Tubing), 320-323
Semi-red brass, leaded, cast, 98
Sheet felts, 242
Sheet metal parts, 303-307
Sheet molded parts, thermoplastic, 313 ff.
Shell mold castings (see also Castings), 296 ff.
Shellac adhesives, 386 ff.
Silica
Glass, 234
Refractory, 231
Silicate adhesives, 386 ft.
Silicon carbide, 232
Silicone
Adhesives, 386 ff.
Coatings, 267, 268
Foams, 180
Plastics (see also Plastics Parts), 160
Rubber, 177
Siliconized surfaces, 258
Silk fiber, 240
Silver
Adhesive-bonded, 386 ff.
As a cladding or precoating, 272 ff.
Brazed, 374 ff.
Brazing alloys, 374 ff.
Clad and precoated, 272 ff.
Hard coatings and surfaces, comparison of, 258
Joinability, 372
Mechanically fastened, 389 ff.
Properties, 114
Solders, 374 ff.
Sintered parts (see Metal Powder Parts)
Sisal fibers, 240
Soda-lime glass, 234
Softboard, 241
Soldering
Alloys, 374-377
Joinability of materials, 372
Specific gravity, 8
Spinnings, 319
Compared with other forms, 294
Sprayed metal coatings
Compared with other hard coatings, 258
Properties, 265
Stamped parts (see also Press Formed Parts), 303 ff.
Compared with other forms, 294
Stapling, 389 ff.
Starch adhesives, 386 ff.
Steatite, 229
Steel
Adhesive bonded, 386 ff.
As a sprayed coating, 265
Bending allowances, 305
Brazed, 374
Cadmium electroplated, 264
Steel (cont'd)
Carbon, 38-40
Cast carbon, 56
Cast heat resistant alloy, 62-64
Cast low alloy, 57-58
Cast stainless
Investment cast, 296 ff.
Properties, 59-61
Castings, types of, 296 ff.
Chromium electroplated, 260
Chromium-vanadium, 46
Clad and precoated, 272 ff.
Conversion coated, 259
Forged, 308
Formability, 303 ff.
Forms, comparison of, 294
Free-cutting, 41
High carbon, 40
Hard coatings and surfaces, comparison of, 258
Joinability, 372
Low carbon
Extruded, 300
Impact extruded, 302
Powder metal parts, 316
Properties, 38
Machinability, 318
Manganese, 42
Manganese-nickel-chromium-molybdenum, 48
Manganese-silicon, 48
Mechanically fastened, 389 ff.
Medium carbon, 39
Molybdenum, 44
Nickel, 43
Nickel-chromium-molybdenum, 45, 47
Nickel electroplated, 263
Nitriding grades, 55
Porcelain enameled, 270
Punch penetration, 303
Roll formed, 306
Sheet bend allowances, 305
Soldered, 374 ff.
Spinnability, 319
Stainless
Age-hardening, 55
As a cladding or precoating, 272 ff.
As a sprayed coating, 265
Austenitic, 50
Chromium-manganese, 49
Ferritic, 54
Finishes, mechanical, 266
Formability, 303 ff.
Martensitic, 52
Porcelain enameled, 270
Powder metal parts, 316
Precipitation-hardening, 55
Properties, 50-51
Rubber pad formed, 307
Stamped and press formed, 303 ff.
Tubing, 320-323
Welded, 378 ff.
Welding rods and electrodes, 378 ff.
Zinc electroplated, 264
Stitching, 389 ff.
Strength
Creep, 20
Stress-rupture, 21
Tensile, 14
Stretch formed parts (see also Press Formed Parts), 306
Stud bolts, 389 ff.
Styrenated alkyd coating, 267
Styrene (see also Polystyrene)
Adhesives, 386 ff.
Butadiene-styrene rubber, 176
Surfaces, hard, comparison of, 258
Synthetic fibers, 238

t

Tantalum
Properties, 93
Spinnability, 319
Tantalum carbide, 233
Teflon (see Polytetrafluoroethylene)
Tellurium lead (see also Lead and Its Alloys), 104
Temperature, maximum service, 11
Tensile modulus, 13
Tensile strength, 14
Thermal conductivity, 9
Thermal expansion, coefficient of, 10
Thermoplastics (see also particular plastics)
Adhesive bonded, 386 ff.
Adhesives, 386 ff.
Joinability, 372
Mechanically fastened, 389 ff.
Welded, 372
Thermosets (see also particular plastics)
Adhesive bonded, 386 ff.
Adhesives, 386 ff.
Joinability, 372
Mechanically fastened, 389 ff.
Thiokol (see Polysulfide)
Thoria, 231
Thorium, 103
Threads, 389
Tin and its alloys
Adhesive bonded, 386 ff.
As a cladding or precoating, 272 ff.
As a sprayed coating, 265
Castings, types of, 296 ff.
Extruded, 300
Forms, comparison of, 294
Impact extruded, 302
Mechanically fastened, 389 ff.
Powder metal parts, 316
Properties, 116
Tin-base materials
Babbitts, 117 ff.
Solders, 374 ff.
Titanium and its alloys
Adhesive-bonded, 386 ff.
Brazed, 374 ff.
Chromium electroplated, 260
Conversion coated, 306
Extruded, 300
Forms, comparison of, 294
Hard coatings and surfaces, comparison of, 258
Joinability, 372
Mechanically fastened, 389 ff
Properties, 120
Roll formed, 306
Soldered, 374 ff.
Tubing, 320-323
Welded, 378 ff.
Titanium carbide, 232
Tobin bronze sprayed coating, 265
Transfer molded plastics parts (see also Molded Parts), 311
Tubing, mechanical, 320-323
Compared with other forms, 294
Tungsten
Brazed, 374 ff.
Properties, 93
Tungsten carbide, 232

u

Upset forgings (see also Forgings), 308-310
Uranium, 103
Urea (see also Plastics Parts)
Adhesives, 386 ff.
Coatings, 267, 268
Foam, 181
Plastics, 163
Urethane rubber, 177
Flexible foam, 179
Foamed-in-place, 180

v

Vanadium, 103
Vicara fibers, 239
Vinyl derivative fibers, 239
Vinylidene chloride (see Polyvinyls)
Vinyls (see Polyvinyls)
Vinyon fibers, 239
Viscose fibers, 238
Vulcanized fibre
Bone, 173
Commercial, 171
Design practice, 315
Electrical insulation, 175
Trunk, 171

w

Washers, 389 ff.
Welded parts, compared with other forms, 294
Welded tubing (see also Tubing, Mechanical), 320-323
Welding
Joinability of materials, 372
Rods and electrodes, 378 ff.
White metal (see also Tin and Its Alloys), 116
Whitewares, 228
Woods
Adhesive bonded, 386 ff.
Composition board, 241
Joinability, 372
Mechanically fastened, 389 ff.
Properties, 241
Wool fibers, 240

y

Yellow brass (see also Brass), 95

z

Zinc alloys
Adhesive-bonded, 386 ff.
As a cladding or precoating, 272 ff.
As an electroplate, 264
As a sprayed coating, 265
Brazed, 374 ff.
Cast, 123
Castings, types of, 296 ff.
Chromium electroplated, 260
Clad and precoated, 272 ff.
Extruded, 300
Forms, comparison of, 294
Hard coatings and surfaces, comparison of, 258
Impact extruded, 302
Joinability, 372
Machinability, 318
Mechanically fastened, 389 ff.
Properties, 122-123
Soldered, 374 ff.
Spinnability, 319
Stamped and press formed, 303 ff.
Zircon ceramics, 228
Zirconia, 231
Zirconium, 103
Zirconium carbide, 233

Comparisons of Materials

1

	PAGE
Specific Gravity	8
Thermal Conductivity	9
Coefficient of Thermal Expansion	10
Melting Points of Metals and Ceramics	11
Maximum Service Temperatures of Plastics and Rubber	12
Electrical Resistivity	13
Modulus of Elasticity in Tension	14
Elongation	17
Hardness	19
Creep Strength of Metals	21
Stress-Rupture Strength of Metals	22
Effect of Radiation on Metals	23

Specific Gravity

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Osmium	22.7	—	Melamines	1.74	0.26
Iridium	22.5	—	Vinylidene Chloride	1.71	0.04
Platinum	21.5	—	Vinylidene Chloride Film	1.68	—
Tungsten & Gold	19.4	—	Carbon & Graphite	1.57	0.07
Uranium	19.1	—	Plastics Laminates	1.52	0.38
Tantalum	16.6	—	Bast Fiber	1.51	0.04
Tungsten Carbide Cermet	14.1	1.1	Diallyl Phthalate	1.5	0.2
Hafnium	13	—	Ureas	1.49	0.03
Rhodium	12.4	—	Cellophane	1.48	0.07
Palladium & Ruthenium	12	—	Hard Rubber	1.46	0.26
Tungsten-Titanium Carbide Cermet	11.8	1.2	Animal Fiber	1.45	0.15
Thorium	11.6	—	Acetal	1.43	—
Lead & Its Alloys	11.0	0.3	Polyester Film	1.39	—
Silver	10.5	—	Allyls (cast)	1.38	0.08
Molybdenum	10.2	—	Polyvinyl Chloride	1.35	0.20
Lead-Base Babbitts	9.96	0.66	Polysulfide Rubber	1.35	—
Tin Bronzes (cast), High Leaded	9.18	0.32	Polyvinyl Chloride Films	1.33	0.17
Copper	8.92	0.03	Polystyrenes & Nylons, Glass Fiber-Filled	1.33	0.02
Cobalt	8.92	—	Cellulosic Films	1.30	0.16
Phosphor Bronzes	8.85	0.07	PVC-Nitrile Rubber Blend Film	1.27	0.08
Nickel Silvers	8.77	0.10	Polyvinyl Alcohol	1.26	0.05
Red & Semi-Red Brasses & Tin Bronzes (all cast), Leaded	8.73	0.17	Polyvinyl Alcohol Film	1.26	0.05
Monel	8.66	0.18	Polyesters (cast)	1.25	0.20
Plain Brasses & Nickel	8.62	0.23	Neoprene, Silicone & Urethane Rubbers	1.25	—
Monel (cast)	8.60	0.24	Polycarbonate	1.20	—
Columbium	8.6	—	Polysulfide-Epoxy (cast)	1.19	0.04
Tin & Aluminum Brasses	8.43	0.09	Acrylics	1.18	0.01
Duranickel & Inconel	8.26	0.18	Wood Comp Board, Hard	1.17	0.28
Beryllium Coppers	8.22	0.03	Epoxies (cast)	1.17	0.02
Low Expansion Nickel Alloys	8.14	0.06	Cellulosics	1.15	0.15
Carbon & Low Alloy Steels	7.84	—	Rubber Hydrochloride Film	1.14	0.01
Stainless Steels	7.78	0.25	Nylons 6 & 66	1.13	0.05
Ingot Iron	7.76	—	Polystyrenes	1.06	0.06
Tin-Base Babbitts	7.55	0.21	Polystyrene Film	1.06	0.01
Aluminum Bronzes (cast)	7.48	0.08	Nitrile Rubber	1	—
Chromium Carbide Cermet	7.44	0.46	Polyethylenes	0.94	0.03
Austenitic Nodular Irons	7.43	—	Styrene-Butadiene Rubber	0.94	—
Tin & Its Alloys	7.29	0.03	Natural Rubber	0.93	—
Malleable Irons	7.21	0.08	Polyethylene Film	0.92	—
Gray Irons	7.21	—	Polypropylene	0.91	—
Wrought & Nodular Irons	7.17	0.25	Butyl Rubber	0.9	—
Zinc & Its Alloys	7.17	0.01	Wood Comp Board, Particle	0.73	0.32
Zinc Alloys (cast)	6.65	—	American Woods	0.53	0.16
Zirconium	6.65	—	Epoxy Foamed-in-Place	0.51	0.11
Vanadium	6.38	—	Sheet Felts	0.473	0.217
Titanium Carbide Cermet	6.37	0.83	Cellular Polyethylene	0.47	—
Molybdenum Disilicide	6.08	0.12	Wood Comp Board, Soft	0.41	—
Alumina Cermets	5.96	0.14	Prefoamed Epoxy	0.328	0.280
Titanium & Its Alloys	4.60	0.17	Neoprene Flexible Foam	0.321	0.160
Alumina Ceramics	3.67	0.19	Filter Felts	0.313	0.169
Silicon Nitride	3.43	—	Flexible Nitrile Foam	0.281	0.120
Glasses	3.22	1.06	Prefoamed Silicone Rubber	0.256	—
Micas	3.2	0.6	Roll Felts	0.245	0.092
Whitewares	3.08	0.78	Silicone Rubber Foamed-in-Place	0.208	0.016
Silicon Carbide	2.82	0.24	Urethane Rubber Foamed-in-Place	0.204	0.197
Aluminum & Its Alloys	2.72	0.14	Urethane Flexible Foam	0.168	0.152
Glass Fiber	2.54	—	Prefoamed Modified Polystyrene	0.125	0.015
Boron Carbide	2.41	—	Latex Flexible Foam	0.104	0.008
Boron Nitride	2.24	—	Phenolic Foamed-in-Place	0.096	0.064
Polytetrafluoroethylene	2.2	0.1	Polystyrene Foamed-in-Place	0.096	0.064
Phenolics	2.15	0.85	Cellular Cellulose Acetate	0.096	0.032
Polytetrafluoroethylene Film	2.15	—	Styrene-Butadiene Flexible Foam Rubber	0.072	—
Alkyds	2.12	0.12	Vinyl Flexible Foam	0.064	—
Polytrifluorochloroethylene	2.12	0.03	Prefoamed Polystyrene	0.048	0.019
Polytrifluorochloroethylene Film	2.11	—	Prefoamed Urea	0.016	0.003
Silicone Plastics	1.82	0.18			
Magnesium Alloys	1.81	0.04			

Thermal Conductivity[a]

Btu/hr/sq ft/°F/ft

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Silver[b]	242	—	Titanium Alloys[b]	5.8	0.9
Copper	211	—	Calcia[c]	4.12	—
Gold[b]	172	—	Carbon[b]	4	1
Beryllium Copper	105	—	Ceramics, Elec & Mech	2.06	1.19
Aluminum & Its Alloys	97.8	30.2	Polycrystalline Glass	1.62	0.48
Tungsten[b]	96.6	—	Magnesia[c]	1.47	—
Plain Brasses	88	21	Wood Comp Board, Hard	1.33	0.52
Molybdenum[b]	84.5	—	Silicon Nitride[c]	0.9	—
Graphite[b]	78.8	8.0	Silica[c]	0.80	—
Phosphor Bronzes	74.5	45.5	Glasses[b]	0.63	0.18
Aluminum Alloys (cast)	71.8	20.7	Wood Comp Board, Particle	0.6	0.2
Tin Brasses	65.5	1.5	Zirconia[c]	0.53	—
Zinc & Its Alloys	61.4	0.8	Silicone Plastics	0.529	0.441
Aluminum Brass	58	—	Wood Comp Board, Soft	0.52	0.28
Magnesium Alloys	54.5	25.5	Alkyds, GP	0.475	0.125
Rhodium[b]	50	—	Polyvinyl Alcohol	0.46	—
Magnesium Alloys (cast)	48.4	24.2	Melamines, Filled	0.33	0.08
Platinum[b]	42	—	Micas	0.32	0.09
Palladium[b]	41	—	Phenolics, Elec	0.29	0.05
Cobalt	39.8	—	Alkyds, High Str	0.25	0.05
Ingot Iron[b]	38	—	Cellular Polyethylene	0.25	0.05
Tungsten Carbide Cermet[b]	37.9	12.2	Phenolics, Shock & Ht Res	0.243	0.147
Grade A Tin	37	—	Plastics Laminates, GP	0.23	0.06
Nickel Steels[b]	36.5	2.3	Ureas	0.207	0.037
Wrought Iron[b]	36	—	Polyethylenes	0.19	—
Red Brasses (cast), Leaded	36	—	Silicone Rubber	0.177	0.017
Nickel[b]	35.1	0.9	Plastics Laminates, Elec & Mech	0.17	—
Iridium[b]	34	—	Roll Felts	0.16	0.14
Tin Foil	34	—	Nylons, Soluble	0.16	—
Tantalum[b]	31.5	—	Cellulose Acetate & Propionate	0.145	0.045
Nitriding Steels[b]	30	—	Nitrile Rubber	0.143	—
Standard Malleable Iron	29.5	—	Polytetrafluoroethylene	0.142	—
Gray Irons[b]	29	5	Phenolics, GP	0.133	0.037
Aluminum Bronzes (cast)	27.5	5.5	Cellulose Nitrate Sheet	0.133	—
Tin Bronzes (cast), Leaded	27.5	0.5	Acetal	0.13	—
Carbon & Low Alloy Steels[b]	27	—	Ethyl Cellulose	0.129	0.038
Tungsten-Titanium Carbide Cermet[b]	24.7	8.2	Acrylics (cast)	0.125	0.025
Nickel-Chromium-Molybdenum Steels[b]	21.7	—	Nylons	0.12	0.02
Nickel Silvers	21.5	—	Acrylics	0.12	—
Thorium	21.4	—	Allyls (cast)	0.118	0.003
Soft Leads[b]	19.5	0.2	Neoprene Rubber	0.112	—
Nodular Irons[b]	19	1	Polyesters (cast), Rigid	0.11	0.01
Hard Lead Alloys[b]	17.5	1.5	Polycarbonate	0.11	—
Silicon Carbide[c]	17	8	Epoxies (cast)	0.101	0.005
Boron Carbide[c]	16	—	Polyvinyl Formal	0.089	—
Boron Nitride[c]	15.4	—	Polyvinyl Chloride	0.085	0.015
Stainless Steels[b]	15.3	5.9	Natural Rubber	0.082	—
Nickel Silvers (cast)	15	1	Rubber Phenolics	0.08	0.04
Uranium	14.5	—	Polypropylene	0.08	—
Lead-Base Babbitts[b]	14	—	Polystyrenes, GP	0.069	0.011
Monel[b]	13.1	2.3	Epoxy Foamed-in-Place	0.067	—
Tantalum Carbide	12.8	—	Mod Polystyrenes	0.054	0.006
Zirconium Carbide	11.9	—	Vinylidene Chloride	0.053	—
High Alloy Steels (cast)[b]	11.4	3.8	Butyl Rubber	0.053	—
Stainless Steels (cast)[b]	11.3	3.2	Polytrifluorochloroethylene	0.035	—
Duranickel[b]	11	2	Prefoamed Epoxy	0.034	0.120
Titanium Carbide	9.9	—	Cellular Cellulose Acetate	0.026	0.002
Titanium[b]	9.8	—	Urethane Rubber Foamed-in-Place	0.025	0.005
Zirconium[b]	9.6	—	Neoprene Flexible Foam	0.025	0.004
Beryllia[c]	9.52	—	Silicone Rubber Foam	0.025	—
Austenitic Stainless Steels[b]	9.4	—	Latex & Nitrile Flexible Foams	0.023	0.002
Inconel[b]	8.7	—	Prefoamed Polystyrene	0.022	0.002
Alumina Ceramics[b]	8.5	2.3	Phenolic Foamed-in-Place	0.021	0.002
Columbium Carbide	8.23	—	Polystyrene Foamed-in-Place	0.020	0.002
Low Expansion Nickel Alloys[b]	6.48	0.43	Styrene-Butadiene Flexible Foam	0.018	—
			Prefoamed Urea	0.016	0.002
			Thoria[c]	0	—

[a] Values at room temperature except where noted.
[b] Value at temperature between 120 and 212 F.
[c] Value at temperature >1800 F.

Coefficient of Thermal Expansion[a]

10^{-6} in./in./°F

Material ↓	Average	Range, ±
Polyethylene[d]	118	49
Vinylidene Chloride[d]	87.8	—
Polyvinyl Butyral[d]	85.5	41.5
Cellulosics[d]	77	33
Mod Polystyrenes, Extra High Impact[d]	73	26
Polypropylene[d]	62	—
Nylons[d]	58.5	12.5
Polytetrafluoroethylene[d]	55	—
Polyvinyl Alcohol[d]	52.6	13.9
Acrylics (cast)[d]	50	—
Polyester (cast), Rigid[d]	47.5	8.5
Acetal[d]	45	—
Phenolics (cast), Decorative[d]	44	11
Allyls (cast)[d]	42	14
Mod Polystyrenes	40	7
Hard Rubber[d]	40	—
Polycarbonate[d]	39	—
Polytrifluorochloroethylene[d]	38.8	—
Polystyrenes, GP[d]	38.5	5.5
Phenolics (cast), Mech & Cml[d]	38.5	5.4
Epoxies (cast)[d]	38.3	11.7
Prefoamed Polystyrene[d]	35	15
Acrylics[d]	35	5
Plastics Laminates, GP[d]	34.5	23.5
Polysulfide-Epoxy (cast)[d]	33	22
Polyvinyl Chloride, Rigid[d]	30.5	2.5
Silicone Plastics, GP[d]	30.1	2.2
Urethane Rubber Foamed-in-Place[d]	29.5	14.5
Epoxy Foamed-in-Place[d]	25.2	14.8
Silicone Rubber Foamed-in-Place[d]	22.5	2.5
Cellular Cellulose Acetate[d]	22.5	2.5
Melamines, Filled[d]	21.1	10.6
Phenolics, GP	20.8	4.2
Micas[d]	20.7	6.3
Alkyds[d]	20	10
Prefoamed Epoxy[d]	19	3
Zinc and Its Alloys[d]	18.9	0.5
Soft Leads[d]	16.3	—
Phenolics, Shock & Ht Res[d]	15.6	7.4
Hard Lead Alloys	15.2	0.8
Zinc Alloys (cast)	15.2	—
Rubber Phenolics[d]	15.1	6.9
Magnesium Alloys	15	1
Aluminum & Its Alloys	13.9	0.6
Ureas[d]	13.6	1.4
Grade A Tin	13	—
Lead-Base Babbitts	12.7	1.9
Phenolics, Elec[d]	12.5	1.9
Aluminum Alloys (cast)	12.5	1.1
Uranium	12.1	—
Silver	10.9	—
Copper & Its Alloys	10.4	1.4
Austenitic Nodular Irons	10.4	—
Chromium-Manganese Stainless Steels	9.95	.25
Austenitic Stainless Steels[d]	9.7	0.2
Nickel & Its Alloys (cast)[b]	9.03	0.17
High Alloy Steels (cast)[b]	8.45	2.05
Stainless Steels (cast)[b]	8.4	2
Free-Cutting Steels[b]	8.4	—
Medium & Low Carbon Steels[b]	8.35	0.05
Molybdenum Steels[b]	8.3	—
Carbon Steels (cast)[b]	8.3	—
Low Alloy Steels (cast)[b]	8.15	0.15
High Carbon Steels[b]	8.1	—
Chromium-Vanadium Steels	8.1	—
Manganese Steels[b]	7.9	—
Gold	7.9	—
Magnesia[c]	7.78	—
Nickel & Its Alloys	7.7	1.3
Calcia[c]	7.55	—
Martensitic Stainless Steels[b]	6.9	0.4
Cobalt[d]	6.8	—
Wrought & Ingot Irons	6.7	0.1
Standard Malleable Irons	6.6	—
Nitriding Steels[b]	6.5	—
Palladium	6.5	—
Titanium Alloys[b]	6.4	0.7
Thorium[d]	6.2	—
Chromium Carbide Cermet	6.05	0.25
Gray Irons	6	—
Titanium Carbide Cermet[b]	5.9	1.6
Ferritic Stainless Steels	5.9	0.2
Age Hardening Stainless Steels	5.85	0.35
Titanium[b]	5.8	—
Beryllium Carbide[b]	5.8	—
Beryllia & Thoria[c]	5.28	—
Plastics Laminates, Mech[d]	5.2	0.9
Ruthenium[d]	5.1	—
Molybdenum Disilicide[c]	5.1	—
Alumina Cermets[b]	4.95	0.25
Soda-Lime Glass	4.95	0.15
Lead Silicate Glass	4.9	0.2
Platinum	4.9	—
Vanadium[d]	4.8	—
Forsterite	4.72	—
Rhodium[d] & Tantalum Carbide[d]	4.6	—
Silicone Plastics, High Impact[d]	4.5	—
Plastics Laminates, Elec[d]	4.45	1.35
Boron Nitride[b]	4.3	—
Titanium Carbide[b]	4.1	—
Alumina Ceramics	3.85	0.15
Columbium[b]	3.82	—
Iridium[d]	3.8	—
Tungsten-Titanium Carbide Cermet[b]	3.75	0.25
Zirconium Carbide[b]	3.7	—
Steatite	3.66	0.33
Tantalum[d]	3.6	—
Osmium[d]	3.6	—
Hafnium[d]	3.4	—
Polycrystalline Glass	3.2	2.5
Tungsten Carbide Cermet[b]	3.2	0.7
Zirconium[d]	3.1	—
Zirconia[c]	3.06	—
Molybdenum[d]	3	—
Silicon Carbide	2.4	—
Aluminum Silicate Glass	2.3	—
Tungsten[d]	2.2	—
Borosilicate Glass	2.15	0.35
Cordierite	2.08	—
Standard Electrical Ceramics	2	—
Boron Carbide	1.73	—
Zircon	1.57	0.27
Carbon	1.4	0.1
Silicon Nitride[b]	1.37	—
Graphite	1.15	0.15
Silica Glass	0.37	0.07
Silica, Vitreous	0.28	—

[a] Values for a temperature *range* except where noted. The lower temperature is room temperature. The higher temperature is a value between 212 and 750 F except where noted.
[b] Value for a temperature range between room temperature and 1200-1650 F.
[c] Value for a temperature range between room temperature and 2200-2875 F.
[d] Value at room temperature only.

Melting Points of Metals and Ceramics

Fahrenheit

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Tungsten	6152	—	Boron Nitride	3000	—	Nodular Irons	2150	100
Thoria	6000	—	Palladium	2829	—	Uranium	2071	—
Tantalum	5425	—	Ceramic Fiber	2800	—	Glass Fiber	2000	500
Magnesia	5070	—	96% Silica Glass	2800	—	Copper	1960	20
Osmium	4890	—	Ingot Iron	2794	—	Gold	1945	—
Molybdenum	4760	—	Wrought Iron	2750	—	Copper Alloys	1790	160
Calcia	4710	—	Low & Medium Carbon			Silver	1761	—
Zirconia	4710	—	Steels	2735	35	Copper Alloys (cast)	1695	145
Beryllia	4620	—	Nickel-Chromium-			Aluminum Silicate Glass	1675	—
Ruthenium	4530	—	Molybdenum Steels	2740	—	Other Silicate &		
Iridium	4450	—	Cobalt	2723	—	Soda-Lime Glasses	1290	210
Columbium	4379	—	Ferritic Stainless Steels	2695	95	Aluminum & Its Alloys	1070	140
Molybdenum Disilicide	3685	90	Martensitic Stainless			Magnesium Alloys	1010	190
Rhodium	3571	—	Steels	2650	150	Zinc & Its Alloys	756	36
Silicon Nitride	3452	—	Stainless Steels (cast)	2650	100	Soft Lead	620	3
Hafnium	3400	—	Nickel	2620	10	Tin-Base Babbitts	570	220
Alumina Cermets	3362	—	Austenitic Stainless			Hard Lead Alloys	550	60
Zirconium	3355	—	Steels	2600	50	Pewter	520	45
Platinum	3224	—	Nickel Steels	2600	20	Lead-Base Babbitts	500	40
Titanium	3135	—	High Alloy Steels (cast)	2550	200	White Metal	475	—
Vanadium	3100	—	Nickel (cast)	2520	75	Hard Tin	443	—
Thorium	3074	—	Asbestos Fiber	2470	300	Tin Foil	390	—
Fused Silica Glass	3050	—	Nickel Alloys	2458	158			

Maximum Service Temperatures of Plastics and Rubber

Fahrenheit

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Polytetrafluoroethylene			Nylon 66	290	12	Polyethylene Film	200	—
Film	575	10	Vinylidene Chloride Film	290	—	PVC-Nitrile Rubber		
Silicone Rubber	550	—	Plastics Laminates, Elec	280	120	Blend Film	200	—
Polytetrafluoroethylene	500	—	Cellular Cellulose			Vinylidene Chloride	191	21
Polyester Film	490	—	Acetate	270	75	Acetal	185	—
Silicone Plastics	450	—	Polysulfide-Epoxy (cast)	270	25	Polyvinyl Chloride, Non-		
Fluorinated Acrylic			Polyester (cast), Rigid	270	25	rigid	180	40
Rubber	450	—	Plastics Laminates, GP	270	25	Mod Polystyrenes, Ht &		
Polytrifluorochloro-			Urethane Rubber			Cml Res	180	8
ethylene	380	—	Foamed-in-Place	270	25	Natural Rubber	180	—
Diallyl Phthalate	370	75	Rubber Phenolics	260	45	Styrene-Butadiene		
Phenolics, Shock &			Melamines, Fabric-Filled	250	—	Rubber	180	—
Ht Res	350	100	Nitrile Rubber	250	—	Neoprene Flexible Foam	180	—
Melamines, Glass Fiber-			Polysulfide Rubber	250	—	Polystyrene Foamed-in-		
Filled	350	50	Neoprene Rubber	240	—	Place	180	—
Nylon, Glass Fiber-Filled	350	50	Urethane Rubber	240	—	Acrylics	170	30
Alkyds, High Str	350	—	Nylon 6	220	25	Polystyrene Film	170	10
Polytrifluorochloro-			Polyester (cast),			Ureas	170	—
ethylene Film	348	47	Nonrigid	220	25	Polyvinyl Chloride		
Cellophane	338	37	Plastics Laminates,			Film, Nonrigid	165	15
Phenolics, Elec	325	75	Mech	220	25	Polystyrenes, GP	160	20
Alkyds, GP	320	25	Nylon 610	220	—	Polyvinyl Chloride, Rigid	160	8
Phenolics, GP	320	25	Hard Rubber, GP	220	—	Prefoamed Polystyrene	160	5
Prefoamed Epoxy	320	25	Polyvinyl Chloride			Latex Flexible Foam	160	—
Cellulose Acetate Film	300	100	Film, Rigid	210	10	Styrene-Butadiene		
Melamines, Cellulose or			Polymethylstyrene	210	1	Flexible Foam	160	—
Mineral-Filled	300	95	Melamines, Unfilled	210	—	Polyvinyl Formal	150	17
Butyl Rubber	300	50	Nitrile Flexible Foam	210	—	Mod Polystyrenes, Med		
Epoxies (cast)	300	—	Rubber Hydrochloride			& High Impact	140	20
Allyls (cast)	300	—	Film	205	—	Cellulose Nitrate Film	140	—
Phenolic Foamed-in-			Urethane Flexible Foam	200	—	Nylons, Soluble	140	—
Place	300	—	Prefoamed Urea	200	—	Polyvinyl Butyral	110	—

Electrical Resistivity[a]

Microhm-cm

Material ↓	Range
Polytetrafluoroethylene	10^{25}
Polystyrenes, GP	10^{24}-10^{25}
Polytrifluorochloroethylene	10^{24}
Polyethylene	10^{23}-10^{25}
Polypropylene	$>10^{22}$
Polycarbonate	2.1 x 10^{22}
96% Silica Glass[b]	$>10^{21}$
Nylons, Glass Fiber-Filled	4.9-5.7 x 10^{21}
Mod Polystyrenes, Med & High Impact	10^{21}-10^{23}
Acrylics (cast)	10^{21}
Aluminum Silicate Glass[b]	10^{21}
Fused Silica Glass[b]	10^{21}
Polystyrenes, Glass Fiber-Filled	1-67 x 10^{20}
Urethane Rubber Flexible Foam	6.8-8.3 x 10^{20}
Vinylidene Chloride	10^{20}-10^{22}
Mod Polystyrenes, Extra High Impact	10^{20}-10^{22}
Alumina Whitewares	10^{20}-10^{21}
Acrylics & Alkyds	10^{20}
Cordierite, Forsterite & Steatite	10^{20}
Lead Silicate Glass[b]	10^{20}
Polyvinyl Butyral	10^{20}
Polyvinyl Chloride, Rigid	10^{20}
Zircon Whitewares	10^{20}
Allyls (cast)	$>10^{19}$
Acetal	>4 x 10^{19}
Silicone Plastics	>3.4 x 10^{19}
Nylon 66	4.5 x 10^{19}
Boron Nitride	1.7 x 10^{19}
Micas	10^{19}-10^{23}
Mod Polystyrenes, Ht & Cml Res	10^{19}-10^{23}
Nylon 6	10^{19}-10^{21}
Standard Electrical Whitewares	10^{19}-10^{21}
Epoxy Foamed-in-Place	10^{19}
Polyesters (cast), Rigid	10^{19}
Epoxies (cast)	>8 x 10^{18}
Phenolics, Elec	6-10 x 10^{18}
Polysulfide-Epoxy (cast)	1.3-15 x 10^{18}
Phenolics (cast), Mech & Cml	1-7 x 10^{18}
Phenolics (cast), Decorative	1-3 x 10^{18}
Cellulose Propionate	10^{18}-10^{21}
Ethyl Cellulose	10^{18}-10^{20}
Borosilicate Glass[b]	10^{18}
Polyesters (cast), Nonrigid	10^{18}
Polyvinyl Chloride, Nonrigid	4-7000 x 10^{17}
Phenolics (cast), Transparent	3 x 10^{17}
Polymethylstyrenes	2.6-2600 x 10^{17}
Glass Fiber	2 x 10^{17}-10^{21}
Melamines, Glass Fiber-Filled	1-7 x 10^{17}
Cellulose Nitrate Sheet	1.0-1.5 x 10^{17}
Melamines, Cellulose and/or Mineral-Filled	10^{17}-10^{20}
Ureas	5-50 x 10^{16}
Cellulose Acetate	10^{16}-10^{19}
Phenolics, Shock & Ht Res	10^{16}-10^{19}
Cellulose Acetate Butyrate	10^{16}-10^{18}
Polycrystalline Glass	10^{16}
Soda-Lime Glass[b]	4 x 10^{15}
Phenolics, GP	10^{15}-10^{19}
Melamines, Fabric-Filled	10^{15}-10^{18}
Diallyl Phthalate	1-250 x 10^{14}
Rubber Phenolics	10^{12}-10^{17}
Beryllium Carbide	1.1 x 10^{6}
Carbon	3500-4600
Graphite	800-1300
Titanium Alloys	118
Titanium Carbide	105
Austenitic Nodular Irons	102
Inconel	98.1
Columbium Carbide	74
Austenitic Stainless Steels	72
Age Hardening Stainless Steels	71-100
Stainless Steels (cast)	71-90
High Alloy Steels (cast)	70-112
Chromium-Manganese Stainless Steels	69
Nodular Irons	66-68
Zirconium Carbide	63.4
Ferritic Stainless Steels	60-67
Titanium	55
Monel (cast)[c]	53.2-63.1
Gray Irons	50-200
Monel	48.2-58.3
Low Expansion Nickel Alloys	48-81
Duranickel[c]	46.5
Martensitic Stainless Steels	40-72
Zirconium	40
Pearlitic Malleable Irons	38.2-41.2
Standard Malleable Irons	32
Nickel-Chromium-Molybdenum Steels[b]	30
Hafnium[c]	30
Nitriding Steels	27-29
Nickel Steels, Ann.[b]	27-29
Lead-Base Babbitts	25.6-28.7
Uranium	25-50
Vanadium	25
Hard Lead Alloys	22.0-27.1
Chromium-Vanadium Steels	21.0
Nickel (cast)[c]	20.8
Soft Leads	20.6
Tantalum Carbide	20
Manganese-Silicon & Manganese-Nickel-Chromium-Molybdenum Steels	19-20
Molybdenum Steels	19
Medium Carbon Steels	19
Thorium	18
High Carbon Steels	18
Manganese Steels	17
Low Alloy Steels	15-20
White Metal	15
Platinum[c]	14.9
Free-Cutting Steels	14.3
Low Carbon Steels	14.3
Columbium	14.2
Magnesium Alloys (cast), Sol'n Tr	14.0-17.5
Carbon Steels (cast)	13-16
Tantalum	12.4
Tin Foil	12
Inconel (cast)[c]	11.6-12.6
Grade A Tin	11.5
Palladium	10.8
Ingot Iron	9.7
Nickel[c]	9.5
Osmium	9.5
Admiralty Metal, Ann.	8.9
Ruthenium[c]	7.6
Aluminum Bronzes (cast)	7.5-13.5
Aluminum Brass, Ann.	7.5
Manganese Bronze, Ann.	7.2
Zinc Alloys (cast)	6.37-6.54
Zinc Alloys (HR)	6.22-6.31
Zinc (CR)	6.10
Magnesium Alloys (cast)	6.6-17
Naval Brass, Ann.	6.6
Yellow Brass, Ann.	6.4
Muntz Metal, Ann.	6.2
Cartridge Brass, 70%, Ann.	6.2
Zinc (HR)	6.06
Aluminum & Its Alloys, T4	5.75
Tungsten[c]	5.5
Low Brass, 80%, Ann.	5.4
Iridium	5.3
Molybdenum[c]	5.2
Magnesium Alloys	5-14.5
Beryllium Coppers, Ann.	4.82-5.82
Rhodium	4.51
Red Brass, 85%, Ann.	4.7
Commercial Bronze, 90%, Ann.	3.9
Phosphor Bronzes, Ann.	3.6-16
Gilding, 95%, Ann.	3.1
Aluminum & Its Alloys, Ann.	2.93-5.94
Gold[c]	2.35
Copper, Ann.	1.71-2.03
Silver	1.59

[a] Values or ranges at room temperature except where noted.
[b] Value or range at a temperature between 120 and 212 F.
[c] Value or range at 32 F.

Modulus of Elasticity in Tension[a]

100,000 psi

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Osmium	800	—	Gold	120	—
Tungsten Carbide	780	164	Semi-Red Brasses (cast), Leaded	110	33
Iridium	740	—	Silver	110	—
Tungsten-Titanium Carbide Cermet	731	76	Tin Bronzes (cast), Leaded	106	21
Silicon Carbon, Densified	680	—	Aluminum & Its Alloys	104	4
Ruthenium	600	—	Thorium	100	—
Tungsten	500	—	Standard Electrical Ceramics	100	—
Titanium Carbide Cermet	495	75	Fused Silica Glass	100	—
Boron Carbide	420	—	96% Silica Glass	97	—
Molybdenum	420	—	Mica, Glass-Bonded	95	25
Rhodium	420	—	Soda-Lime Glass	95	5
Alumina Ceramics	410	90	Borosilicate Glass	83	15
Alumina Cermets	390	20	Lead Silicate Glass	83	7
Inconel	310	—	Pewter	77	—
Cobalt	300	—	Tin-Base Babbitts	74.5	1.5
Nickel	300	—	Cordierite	70	—
Duranickel	300	—	Magnesium Alloys	65	—
Uranium	300	—	Grade A Tin	62.5	2.5
Carbon Steels (cast)	299	2	Epoxy Foamed-in-Place	60	—
Ingot Iron	298	—	Lead-Base Babbitts	42	—
Carbon & Low Alloy Steels	295	5	Phenolics, Elec	40	10
Wrought Iron	290	—	Phenolics, Shock & Ht Res	20.5	12.5
Martensitic Stainless Steels	290	—	Lead & Its Alloys	20	—
Ferritic Stainless Steels	290	—	Carbon	19.5	3.5
Age Hardening Stainless Steels	288	7	Haynes Stellite 21	16.8	—
Chromium-Manganese Stainless Steels	283	3	Melamines, Filled	14.7	4.8
Austenitic Stainless Steels	280	—	Ureas	14.5	1.5
Pearlitic Malleable Irons	280	—	Polystyrenes, Glass Fiber-Filled	12	—
High Alloy Steels (cast)	270	20	Diallyl Phthalate	11.5	5.5
Tantalum	270	—	Graphite	11	3
Stainless Steels (cast)	265	25	Phenolics, GP	10.5	2.5
Monel	260	—	Rubber Phenolics	6.5	2.5
Micas	250	50	Polyvinyl Formal	6	1
Standard Malleable Irons	250	—	Epoxies (cast)	4.95	0.45
Inconel (cast)	240	10	Phenolics (cast), Mech & Cml	4.5	0.5
Monel (cast)	236	6	Polystyrenes, GP	4.5	0.5
Nodular Irons	235	15	Acrylics	4.25	0.75
Low Expansion Nickel Alloys	225	15	Nylon 66	4.05	0.05
Nickel (cast)	215	—	Polyesters (cast), Rigid	4.0	2.5
Platinum	210	—	Mod Polystyrenes	4	2
Hafnium & Vanadium	200	—	Phenolics (cast), Decorative	3.75	0.75
Beryllium Coppers	190	—	Polyvinyl Butyral	3.75	0.25
Austenitic Nodular Irons	185	—	Nylons 6 & 610	2.55	1.05
Nickel Silvers	180	20	Allyls (cast)	2.5	0.5
Copper	170	—	Polytrifluorochloroethylene	2.45	0.55
Palladium	170	—	Cellulose Nitrate Sheet	2.05	0.15
Aluminum & Phosphor Bronzes	165	15	Ethyl Cellulose	2.0	1.5
Plain Brasses	160	10	Phenolics (cast), Transparent	2	1
Tin & Aluminum Brasses	155	5	Polysulfide-Epoxy (cast)	1.75	1.74
Titanium & Its Alloys	154	5	Polypropylene	1.55	—
Silicon Carbide, Bonded	150	20	Vinylidene Chloride	1.35	0.60
Polycrystalline Glass	149	24	Polyethylene, High Density	1.2	0.4
Gray Irons	145	55	Cellulose Propionate	1.1	0.6
Steatite	145	15	Polyethylene, Medium Density	0.625	0.275
Zirconium	140	—	Polytetrafluoroethylene	0.515	0.135
Tin Bronzes (cast), High Leaded	133	27	Nylons, Soluble	0.38	—
Boron Nitride	124	—	Polycarbonate	0.33	—
Red Brasses (cast), Leaded	120	29	Polyethylene, Low Density	0.235	0.035
			Polyvinyl Chloride, Nonrigid	0.017	0.013

[a] At room temperature.

Tensile Strength[a]

1000 psi

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Rhodium, CW	300	—	Cobalt, CW	100	—
Manganese-Silicon & Manganese-Nickel-Chromium-Molybdenum Steels, H & T (800 F)	225	33	Molybdenum Steels, CD & Ann.	98	11
Nickel-Chromium-Molybdenum Steels, H & T (800 F)	215	5	Austenitic Stainless Steels, Ann.	97	13
Stainless Steels (cast), H & T	210	10	Manganese Steels, Ann.	97	13
Glass Fiber	208	4	Stainless Steels (cast), Ann.	96	1
Beryllium Coppers, CW & Ht Tr	195	15	Martensitic Stainless Steels, Ann.	95	30
Nitrided Steels, H & T	190	—	High Alloy Steels (cast), Ann.	95	—
Molybdenum Steels, H & T	188	80	Medium Carbon Steels, CW	94	9
Martensitic Stainless Steels, H & T	187	98	Titanium, Ann.	94	6
Tungsten, CW	185	120	Inconel (cast)	92	28
Monel, Age H	185	15	Nickel-Chromium-Molybdenum Steels (86xx, 87xx), Ann.	91	14
Beryllium Coppers, Ann. & Ht Tr	175	10	Free-Cutting Steel, CD	90	20
Age Hardening Stainless Steels, Sol'n Tr & Aged	173	42	Nickel Steel, Ann.	90	14
Titanium Alloys, Ht Tr	170	—	Uranium	90	—
High Carbon Steels, H & T (700 F)	169	20	Monel, Ann.	87	18
Nickel-Chromium-Molybdenum Steels, H & T (800 F)	168	46	Zirconium, CW	86	4
Inconel, Age H	167	13	Manganese Bronze, Half Hard	84	—
Asbestos Fiber	158	142	Ferritic Stainless Steels, CW	82	8
Low Alloy Steels (cast), H & T	155	45	Titanium Carbide Cermet	80	54
Austenitic Stainless Steels, CW	147	38	Cartridge Brass, 70%, Hard	76	—
Molybdenum, CW	147	28	Low Expansion Nickel Alloys, Ann.	76	6
Chromium-Vanadium Steels, H & T	146	41	Tantalum, Ann.	75	25
Tantalum, CW	145	35	Pearlitic Malleable Irons	75	15
Chromium-Manganese Stainless Steels, CW	138	12	Ferritic Stainless Steels, Ann.	75	10
Titanium Alloys, Ann.	137	18	Naval Brass, Half Hard	75	—
Tungsten-Titanium Carbide Cermet	132	13	Low Brass, 80%, Hard	74	—
Monel (cast), Ann. & Aged	132	13	Yellow Brass, Hard	74	—
Tungsten Carbide Cermet	130	—	Ingot Iron, CD	73	—
Aluminum Silicate Glass	125	17	Rhodium, Ann.	73	—
High Carbon Steels (HR)	127	—	Beryllium Coppers, CW	72	—
Nickel Steels, H & T (1000 F)	122	18	Vanadium, Ann.	72	—
Sheet Felts	122	10	Beryllium Coppers, Ann.	70	10
Inconel, Ann.	120	10	Aluminum & Its Alloys, T6	70	—
Manganese Steels, H & T (1000 F)	118	18	Red Brass, 85%, Hard	70	—
Phosphor Bronzes, Hard	117	11	Muntz Metal, Half Hard	70	—
Low Expansion Nickel Alloys, CW	115	25	Low Carbon Steels, CW	69	13
Molybdenum Steels, CD	113	24	Manganese Bronze, Ann.	65	—
Vanadium, CW	113	—	Austenitic Nodular Irons	63	5
Roll Felts	112	13	Nickel, Ann.	62	13
Phosphor Bronzes, Hard	111	36	Aluminum Brass, Ann.	60	—
Manganese Steels, CD	110	9	Cobalt, Ann.	56	19
Medium Carbon Steels, H & T (1000 F)	109	11	Gilding, 95%, Hard	56	—
High Carbon Steels, Ann.	108	11	Nickel (cast)	57	8
Molybdenum, Ann.	107	23	Naval Brass, Ann.	57	—
Nickel-Chromium-Molybdenum Steels (43xx), Ann.	107	12	Nickel Silvers, Ann.	55	6
High Alloy Steels (cast), Norm. & T	107	—	Standard Malleable Irons	55	5
Nodular Irons	105	45	Commercial Bronze, 90%, Hard	54	—
Duranickel, Ann.	105	15	Muntz Metal, Ann.	54	—
Chromium-Manganese Stainless Steels, Ann.	105	10	Silver, CW	54	—
Aluminum Bronzes (sand cast), H & T (1000-1150 F)	102	13	Phosphor Bronzes, Ann.	53	13
Nickel Steels, CD	102	8	Admiralty Metal, Ann.	53	—
Columbium, CW	100	—	Columbium, Ann.	50	—
Nickel Silvers, Extra Hard	100	8	Roll Felts	50	33
Carbon Steels (cast), H & T	100	—	Copper, Hard	50	—
			Nickel Silvers (sand cast)	47	18
			Cobalt (cast)	47	14
			Palladium, CW	47	—
			Yellow Brass, Ann.	46	—
			Gray Irons (cast)	45	30
			Micas	45	5
			Zinc Alloys (die cast)	44	3
			Zirconium, Ann.	44	15
			Aluminum Alloys (cast), Sol'n Tr & Aged	44	4

[a] At room temperature.

Tensile Strength—concluded

1000 psi

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Cartridge Brass, 70%, Ann.	44	—	Polysulfide-Epoxy (cast)	6.5	3.5
Ingot Iron, Ann.	42	—	Polytrifluorochloroethylene	6.4	0.2
Low Brass, 80%, Ann.	42	—	Rubber Phenolics	6.2	2.8
Magnesium Alloys (forged)	41	8	Polyvinyl Butyral	6.2	2.3
Tin Bronzes (cast), High Leaded	40	8	Vinylidene Chloride	6	2
Platinum, CW	39	6	Mica, Glass-Bonded	6	1
Red Brass, 85%, Ann.	39	—	Urethane Rubber (gum)	>5	—
Red Brass (cast), Leaded	38	8	Diallyl Phthalate	5.8	1.2
Thorium	37	—	Allyls (cast)	5.7	1.3
Chromium Carbide	36	1	Nylons, Soluble	5.6	1.8
Semi-Red Brass (cast), Leaded	34	6	Rubber Hydrochloride Film	5.5	0.5
Copper, Ann.	32	—	Hard Lead Alloys (chill cast)	5.4	2
Gold, CW	32	—	Hard Rubber	5.1	3.2
Magnesium Alloys (cast)	31	9	Mod Polystyrenes, Med & High Impact	5.1	1.7
Tin Bronzes (cast), Leaded	31	7	Polytrifluorochloroethylene	5.1	0.6
Nickel Silvers (sand cast)	30	2	Cellulosics	5.0	3.5
Palladium, Ann.	30	—	Polypropylene	5	—
Alumina Ceramics	29	10	Standard Electrical Ceramics	4.7	2.3
Vinylidene Chloride, Oriented	27	13	Silicone Plastics, High Impact	4.7	0.3
Zinc (CR)	26	5	Polyethylene, High Density	4.5	1.0
Aluminum Alloys (cast)	23	5	Wood Comp Board	4.4	4.3
Polyester Film	22	6	Silicone Plastics, GP	4.1	0.2
Boron Carbide	22.5	—	Natural Rubber	4.0	0.5
Plastics Laminates	22	15	Hard Tin (CR)	4.0	—
Silver, Ann.	22	—	Mod Polystyrenes, Extra High Impact	3.7	0.8
Platinum, Ann.	21	5	Nitrile Rubber (black)	3.7	0.8
Alumina Cermets	21	—	Phenolics (cast), Transparent	3.5	1.0
Gold, Ann.	19	—	Alkyds, GP	3.5	0.5
Gold (cast)	18	—	Polyvinyl Alcohol	3	2
Nylons, Glass Fiber-Filled	16	4	Polyvinyl Chloride Film, Nonrigid	3	2
Silver (cast)	15	—	Styrene-Butadiene Rubber (black)	3.0	0.5
Silicon Carbide	14	11	Natural Rubber (gum)	3.0	0.5
Cellophane	13	6	Cordierite	3	—
Polystyrenes, Glass Fiber-Filled	12	2	Grade A Tin (CR)	2.8	—
Nylons 6 & 66	11	1	PVC-Nitrile Rubber Blend Film	2.7	1.3
Vinylidene Chloride Film	11	4	Butyl Rubber	2.7	0.3
Tin-Base Babbitts (chill cast)	10	2	Polytetrafluoroethylene Film	2.5	0.5
Forsterite	10	—	Polyethylene Film	2.3	0.7
Epoxies (cast)	10	2	Polyvinyl Chloride, Nonrigid	2.2	1.3
Cellulosic Films	10	4	Polytetrafluoroethylene	2.2	0.8
Polyvinyl Formal	10	1	Grade A Tin, Ann.	2.2	—
Mod Polystyrenes, Ht & Cml Res	10	1	Soft Leads (chill cast or extr)	2.1	0.1
Acetal	10	—	Polyethylene, Medium Density	2.0	0.5
Steatite	9.9	5.1	Polyethylene, Low Density	1.9	0.6
Polycarbonate	9.7	0.8	Soft Leads (sand cast)	1.8	—
Polystyrene Film	9.5	2.5	Polyesters (cast), Nonrigid	1.4	0.5
Acrylics	9.2	1.3	Graphite	1.2	0.8
Tin Foil (CR)	8.7	—	Fluorinated Acrylic Rubber (gum)	1.2	—
Lead-Base Babbitts (chill cast)	8.6	1.9	Polysulfide Rubber (gum)	>1	—
Pewter, Ann.	8.6	—	Carbon	1.0	0.1
Nylon 610	8.5	—	Epoxy Foamed-in-Place	0.9	—
Zircon	8.2	3.8	Silicone Rubber (gum)	0.8	0.2
Acrylics (cast)	8	2	Nitrile Rubber (gum)	0.7	0.2
Alkyds, High Str	8	2	Cellular Polyethylene	0.67	—
Polyvinyl Alcohol Film	8	2	Prefoamed Modified Polystyrene	0.58	0.52
Polymethylstyrenes	7.8	1.2	Urethane Rubber Foamed-in-Place	0.50	0.49
Melamines, Filled	7.5	2.5	Styrene-Butadiene Rubber (gum)	0.25	0.05
Ureas	7.5	2.5	Cellular Cellulose Acetate	0.15	0.03
Polyvinyl Chloride Film, Rigid	7.5	1	Prefoamed Polystyrene	0.11	0.08
White Metal (CR)	7.4	—	Vinyl Flexible Foam	0.10	0.09
Polyvinyl Chloride, Rigid	7.2	1.8	Polystyrene Foamed-in-Place	0.08	0.05
White Metal (cast)	7.2	—	Neoprene Flexible Foam	0.06	0.04
Phenolics	7	3	Phenolic Foamed-in-Place	0.039	0.035
Polyesters (cast), Rigid	7	3	Latex Flexible Foam	0.015	0.005
Polystyrenes, GP	6.7	1.8			
White Metal, Ann.	6.7	—			

Elongation*

Percent

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Butyl Rubber (gum)	850	100	Gold, Ann.	45	—
Neoprene Rubber (gum)	850	50	Muntz Metal, Ann.	45	—
Natural Rubber (gum)	800	50	Grade A Tin, Ann.	45	—
Butyl Rubber (black)	750	100	Cellulose Acetate Film	43	27
Urethane Rubber (gum)	640	110	Soft Leads (chill cast)	43	4
Polypropylene	600	100	Beryllium Coppers, Ann.	42	8
Natural Rubber (black)	600	50	Cellulose Acetate, Soft	41	9
Nitrile Rubber	575	125	Zinc (CR)	40	10
Polysulfide Rubber (gum)	550	100	Leaded Naval Brass, Ann.	40	—
Neoprene Rubber (black)	550	50	Tin Foil (CR)	40	—
Polyethylene Film	500	300	Pewter, Ann.	40	—
Polyvinyl Alcohol Film	500	100	Thorium	40	—
Styrene-Butadiene Rubber	500	100	Hard Lead Alloys (rolled)	38	22
Nylons, Soluble	450	150	Low Expansion Nickel Alloys, Ann.	38	3
Polyvinyl Alcohol	450	150	Monel, Ann.	37	13
Rubber Hydrochloride Film	425	75	Stainless Steels (cast), H & T	36	19
Polyethylene, Low Density	403	322	Platinum, Ann.	35	5
Latex Flexible Foam	380	—	Cellulose Nitrate Film	35	5
PVC-Nitrile Rubber Blend Film	375	125	Low Carbon Steel (HR)	35	4
Polyvinyl Chloride, Nonrigid	320	130	Grade A Tin (CR)	35	—
Cellular Polyethylene	310	—	Wrought Iron (HR)	35	—
Nylon 6	300	—	Austenitic Stainless Steels, CW	34	26
Fluorinated Acrylic Rubber (gum)	300	—	Cellophane	33	17
Polyvinyl Chloride Film, Nonrigid	275	225	Vinylidene Chloride Film	33	7
Silicone Rubber (gum)	230	170	Manganese Bronze, Ann.	33	—
Polytetrafluoroethylene	230	120	Polyvinyl Butyral	32	28
Polytetrafluoroethylene Film	225	25	Cellulose Acetate, Medium	32	15
Vinyl Flexible Foam	190	110	Palladium, Ann.	32	8
Polyesters (cast), Nonrigid	170	140	Animal Fibers	31	19
Polytrifluorochloroethylene Film	145	55	Aluminum & Its Alloys, Ann.	31	14
Polyester Film	100	30	Zinc Alloys (HR)	30	20
Duranickel, Ann.	90	40	Columbium, Ann.	30	—
Polycarbonate	80	20	Soft Leads (sand cast)	30	—
Nylons 66 & 610	73	10	Gold (cast)	30	—
White Metal, Ann.	70	—	Chromium-Vanadium Steels, Norm. (1600-1650 F)	29	6
Cartridge Brass, 70%, Ann.	66	—	Tin Bronze (cast), Leaded	28	12
Yellow Brass, Ann.	65	—	Ethyl Cellulose Film	28	7
Admiralty Metal, Ann.	65	—	White Metal (CR)	28	—
Polyethylene, High Density	62	38	Vanadium, Ann.	28	—
Mod Polystyrenes, Extra High Impact	60	40	Zinc Alloys, (CR)	27	17
Silver (cast)	60	—	Nickel-Chromium-Molybdenum Steels (86xx, 87xx), Ann.	27	5
Phosphor Bronzes, Ann.	59	11	Medium Carbon Steels (HR)	27	3
Chromium-Manganese Stainless Steels, Ann.	58	2	Low Carbon Steels, CW	26	9
Polytrifluorochloroethylene	57	30	Carbon Steel (cast), Ann.	26	6
Cellulose Acetate Butyrate	56	18	Nickel Steels, Ann.	26	5
Austenitic Stainless Steels, Ann.	55	5	Zirconium, Ann.	26	—
Cellulose Propionate	55	5	Monel (cast)	25	24
Aluminum Brass, Ann.	55	—	Tantalum, Ann.	25	15
Grade A Tin (cast)	55	—	Red Brass (cast), Leaded	25	10
Low Brass, 80%, Ann.	52	—	Ferritic Stainless Steels, Ann.	25	5
Polysulfide-Epoxy (cast)	50	50	Carbon Steels (cast), Norm. & T	25	1
Nickel, Ann.	50	10	Martensitic Stainless Steels, Ann.	24	11
Soft Leads (rolled)	50	7	Austenitic Nodular Irons	23	17
Pewter (CR)	50	—	Cellulose Acetate, Hard	23	17
Ingot Iron, Ann.	48	—	Manganese Steels, H & T	23	5
Red Brass, 85%, Ann.	48	—	Low Alloy Steels (cast), Norm. & T	23	3
Silver, Ann.	48	—	High Alloy Steels (cast), Ann.	23	—
Zinc (HR)	47	18	Nickel (cast)	22	8
Inconel, Ann.	47	8	Vinylidene Chloride	22	8
Ingot Iron (HR)	47	—	Medium Carbon Steels, H & T (1000 F)	22	5
Naval Brass, Ann.	47	—	Aluminum Bronzes (sand cast)	21	14
Nickel Silvers, Ann.	45	13	Nickel Steels, CD	21	4
Commercial Bronze, 90%, Ann.	45	—	Nickel-Chromium-Molybdenum Steels (43xx), Ann.	21	4
Copper, Ann.	45	—			
Gilding, 95%, Ann.	45	—			

* At room temperature.

Elongation—concluded

Percent

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Manganese Steels, Ann.	21	3	Muntz Metal, Half Hard	10	—
Mod Polystyrenes, Med & High Impact	20	15	Stainless Steels (cast)	8.5	6.5
Nickel Silvers (sand cast)	20	10	Zinc Alloys (die cast)	8.5	1.5
Medium Carbon Steels, CW	20	6	Cartridge Brass, 70%, Hard	8	—
Chromium-Manganese Stainless Steels, CW	20	5	Yellow Brass, Hard	8	—
Ferritic Stainless Steels, CW	20	5	Pearlitic Malleable Irons	7.5	4.5
Hard Lead Alloys (chill cast)	20	4	Beryllium Coppers, Ann. & Ht Tr	7.5	4.5
Manganese-Silicon & Manganese-Nickel-Chromium-Molybdenum Steels, H & T (1200 F)	20	3	Monel, Age H	7.5	2.5
Carbon Steels (cast), H & T	20	—	Nylon, Glass Fiber-Filled	7.5	1.0
Naval Brass, Half Hard	20	—	Magnesium Alloys (cast)	7	5
Low Expansion Nickel Alloys, CW	20	—	Copper, Hard	7	1
Copper, Half Hard	19	6	Low Brass, 80%, Hard	7	—
High Carbon Steels, Ann.	19	5	Cobalt, Ann.	6.5	6.5
Monel, Ann. & Age H	19	5	Polystyrene Film	6.5	2.5
Molybdenum Steel, CD & Ann.	19	3	Zirconium (CW)	5.7	4.3
Nitriding Steels, H & T (1200 F)	19	3	Molybdenum (sintered), Ann.	5.5	1.5
Manganese Bronze, Half Hard	19	2.4	Aluminum Alloys (cast)	5.3	3.7
Age Hardening Stainless Steels, Sol'n Tr	18	12	Cobalt, CW	5	3
Titanium, Ann.	18	4	Beryllium Copper, CW & Ht Tr	5	3
Aluminum & Its Alloys, H14	18	2	Lead-Base Babbitts (chill cast)	5	3
Standard Malleable Irons	17	8	Gilding, 95%, Hard	5	—
Chromium-Vanadium Steels, H & T (300-1200 F)	17	5	Commercial Bronze, 90%, Hard	5	—
Aluminum & Its Alloys, T4	17	5	Red Brass, 85%, Hard	5	—
Nitriding Steels, H & T (1250 F)	17	—	Polyesters (cast), Rigid	5	—
Martensitic Stainless Steels, H & T	16	14	Columbium, CW	5	—
Nickel-Chromium-Molybdenum Steels (86xx, 87xx), H & T (800 F)	16	5	Acrylics (cast)	4.5	2.5
Stainless Steels (cast), Ann.	16	2	Bast Fibers	4	2
Polyvinyl Chloride, Rigid	15	10	Acrylics	4	1
Polyvinyl Chloride Film, Rigid	15	10	High Alloy Steels (cast), Aged 48 Hr (1800 F)	4	—
Free-Cutting Steels, CD	15	5	Gold, CW	4	—
Beryllium Coppers, CW	15	5	Hard Rubber, GP	3	1
Semi-Red Brass (cast), Leaded	15	2	Platinum, CW	3.0	0.5
Acetal	15	—	Magnesium Alloys (cast), Sol'n Tr & Aged	3	2
Nitrided Steels, H & T	15	—	Vanadium, CW	3	—
Leaded Naval Brass, Half Hard	15	—	Aluminum Alloys (cast), Sol'n Tr & Aged	2.8	2.2
Molybdenum Steels, H & T	14	7	Glass Fiber	2.8	0.9
Tin Bronze (cast), High Leaded	14	6	Hard Rubber, Cml Res	2.7	—
Age Hardening Stainless Steels, Aged	14	4	Hard Rubber, High Ht Res	2.6	—
Titanium Alloys, Ann.	14	4	Hard Rubber, High Dielec Str	2.6	—
Tin-Base Babbitts (die cast)	13	9	Inconel (cast), Ann. & Aged	2.5	1.5
Nickel-Chromium-Molybdenum Steels (43xx), H & T (800 F)	13	1	Monel (cast), Ann. & Aged	2.5	1.5
Aluminum & Its Alloys, H34	13	1	Nickel Silvers, Extra Hard	2.5	0.5
Titanium Alloys, Ht Tr	13	—	Hard Fibers	2.5	0.5
Uranium	13	—	Silver, CW	2.5	—
Nodular & Ingot Irons	12	12	Polymethylstyrene	2.3	0.2
Manganese-Silicon & Manganese-Nickel-Chromium-Molybdenum Steels, H & T (800 F)	12	30	Cobalt (cast)	2	2
Low Alloy Steels (cast), H & T	12	8	Mod Polystyrenes, Ht & Cml Res	2	1
Aluminum & Its Alloys, H18	12	3	Haynes Stellite 21, Aged 50 Hr (1300 F)	2	—
High Carbon Steels, H & T	12	2	Polystyrenes, GP	1.9	0.5
Magnesium Alloys (forged)	11	4	Hard Rubber, Low Moisture Abs	1.8	—
Magnesium Alloys (cast), Sol'n Tr	11	1	Rubber Phenolics	1.5	0.8
Inconel (cast)	10	9	Palladium, CW	1.5	—
Aluminum & Its Alloys, H38	10	5	Tantalum, CW	1.2	0.3
Aluminum Bronzes (sand cast), H & T (1000-1150 F)	10	5	Tungsten, CW	1	1
Duranickel, Age H	10	5	Zinc Alloys (chill cast)	1	—
Phosphor Bronzes, Hard	10	3	Ureas	1	—
			Hard Rubber, High Arc Res	1	—
			Polystyrene, Glass Fiber-Filled	0.87	0.13
			Melamines, Fabric-Filled	0.7	0.1
			Phenolics, GP	0.6	0.2
			Melamines, Cellulose or Mineral-Filled	0.45	0.15
			Phenolics, Shock & Ht Res	0.38	0.19
			Phenolics, Elec	0.31	0.22

Hardness of Metals and Ceramics[a]

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Boron Carbide	2800 Knp	—	Nodular Irons	220	80
Titanium Boride	2720 Knp	—	Ruthenium	220	—
Silicon Carbide	2500 Knp	—	Nickel-Chromium-Molybdenum Steels (43xx), Ann.	210	27
Titanium Carbide	2460 Knp	—	Medium Carbon Steels, H & T (1000 F)	210	3
Beryllium Carbide	2300 Knp	—	Low Expansion Nickel Alloys, CW	B101	2
Silicon Nitride	A99	—	Martensitic Stainless Steels, Ann.	200	55
Tungsten-Titanium Carbide	A93	—	Manganese Steels, Ann.	200	22
Zirconium Carbide	2090 Knp	—	Molybdenum Steels, CD & Ann.	200	22
Tantalum Carbide	9+ Mohs	—	Medium Carbon Steels, CW	200	19
Tungsten Carbide	1880 Knp	—	High Carbon Steels, Ann.	200	19
Columbium Carbide	1880 Knp	—	Cast Stainless Steels, Ann.	200	8
Chromium Carbide	A89	—	Nickel Silvers, Hard	B99	—
Beryllia	9 Mohs	—	Free-Cutting Steels, CD	190	40
Alumina Ceramics	9 Mohs	—	Nickel Steels (HR)	190	35
Zircon Ceramics	8 Mohs	—	High Alloy Steels (cast)	190	29
Zirconia	7.5 Mohs	0.5	Medium Carbon Steels (HR)	190	24
Forsterite	7.5 Mohs	—	Nickel-Chromium-Molybdenum Steels (86xx, 87xx), Ann.	190	23
Steatite	7.5 Mohs	—	Stainless Steels (cast)	190	21
Polycrystalline Glass	7.5 Mohs	—	Nickel Steels, Ann.	180	29
Molybdenum Disilicide (hot pressed)	A84	4	High Alloy Steels (cast), Ann.	180	—
Standard Electrical Ceramics	7.2 Mohs	0.2	Pearlitic Malleable Irons	170	12
Thoria	7 Mohs	—	Carbon Steels (cast), Norm. & T	170	7
Cordierite	7 Mohs	—	Iridium, Ann.	170	—
Molybdenum Disilicide (cold pressed)	C57	—	Ferritic Stainless Steels	B93	2
Manganese Steels, H & T (800 F)	450	63	Nickel Silvers, Extra Hard	B93	2
Nickel-Chromium-Molybdenum Steels (43xx), H & T (800 F)	440	5	Vanadium, CW	B93	—
Magnesia	6 Mohs	—	Zirconium, CW	B92	6
Stainless Steels (cast), H & T	430	40	Aluminum Bronzes (sand cast)	160	37
Alumina Cermets	C46	9	Low Expansion Nickel Alloys, Ann.	160	13
Nitrided Steels, H & T	410	—	Iridium (cast)	160	—
Tungsten, CW	C42	5	Chromium-Manganese Stainless Steels, Ann.	B90	—
Beryllium Copper, CW & Ht Tr	C41	3	Yellow Brass, Hard	B90	—
Martensitic Stainless Steels, H & T	380	200	Manganese Bronze, Half Hard	B90	—
Molybdenum Steels, H & T (1000 F)	380	150	Nickel Silvers, Hard	B88	3
Chromium-Vanadium Steels, H & T (1200 F)	380	66	Austenitic Stainless Steels, Ann.	150	5
Age Hardening Stainless Steels, Aged	350	40	Phosphor Bronzes, Hard	B86	11
High Carbon Steels, H & T (700 F)	350	40	Low Carbon Steels, CW	140	25
Osmium (cast)	350	—	Ingot Iron, CD	140	—
Iridium, CW	350	—	Micas	3.5 Mohs	0.5
Inconel (cast), Ann. & Aged	340	40	Ferritic Stainless Steels	B83	7
Monel (cast), Ann. & Aged	340	40	Low Brass, 80%, Hard	B82	—
Duranickel, Age H	C35	5	Cartridge Brass, 70%, Hard	B82	—
Nickel-Chromium-Molybdenum Steels (86xx), H & T (800 F)	330	89	Naval Brass, Half Hard	B82	—
Low Alloy Steels (cast), H & T	320	82	Vanadium, Ann.	B81	—
Rhodium, CW	320	65	Yellow Brass, Hard	B80	—
Age Hardening Stainless Steels, Sol'n Tr	C33	8	Standard Malleable Irons	130	17
Inconel, Ann. & Age H	C33	4	Cobalt, Ann.	130	8
Titanium Alloys, Ann.	C32	6	Aluminum & Its Alloys, T6	130	—
Nitriding Steels, H & T (1200 F)	290	32	Hafnium, Ann.	B78	—
Calcia	4.5 Mohs	—	Red Brass, 85%, Hard	B77	—
Titanium, Ann.	C30	—	Muntz Metal, Half Hard	B75	—
Monel, Age H	C29	5	Low Carbon Steels (HR)	120	21
Inconel (cast)	260	120	Aluminum & Its Alloys, T4	120	15
High Carbon Steels (HR)	260	29	Cobalt (cast)	120	15
Monel (cast)	240	110	Carbon Steels (cast), Ann.	120	—
Austenitic Stainless Steels, CW	240	—	Commercial Bronze, 90%, Hard	B70	—
Gray Irons	230	65	Aluminum Alloys (cast), Sol'n Tr & Aged	115	25
High Alloy Steels (cast), Aged 24 Hr (1400 F)	230	42	Austenitic Stainless Steels, Ann.	110	35
Nickel Steels, CD	230	29	Nickel (cast)	110	20
			Aluminum & Its Alloys, T3	110	12
			Palladium, CW	110	—
			Zirconium, Ann.	B66	25

[a] Values are Rockwell when preceded by letter scale, Mohs where indicated, Knoop when designated Knp; all other values are Brinell. The relative placement of values from different tests is only an approximation.

Hardness of Metals and Ceramics—concluded

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
Gilding, 95%, Hard	B64	—	Platinum, CW	55	42
Wrought Iron (HR)	105	—	Magnesium Alloys (cast)	54	21
Nickel Silvers (sand cast)	100	50	Tin Bronze (cast), High Leaded	53	18
Rhodium, Ann	100	50	Aluminum & Its Alloys, H18	49	6
Columbium, CW	E100	—	Palladium, Ann	46	—
Tantalum, CW	E95	—	Nickel Silvers (sand cast)	H79	1
Aluminum & Its Alloys, T72	95	—	Platinum, Ann	45	7
Nickel, Ann	B59	5	Aluminum & Its Alloys, Ann	44	21
Beryllium Coppers, Ann	B57	8	Copper, Ann	F40	—
Zinc Alloys (die cast)	86	4	Zinc (HR)	42	5
Copper, Hard	B50	—	Silver (cast)	42	—
Ingot Iron (HR)	83	—	Aluminum Alloys (cast)	40	30
Aluminum & Its Alloys, H38	81	18	Aluminum & Its Alloys, H14	36	4
Boron Nitride	2 Mohs	—	Gold (cast)	33	—
Muntz Metal, Ann	F80	—	Silver, Ann	30	5
Copper, Half Hard	B40	—	Gold, Ann	25	—
Tin Bronze (cast), Leaded	70	10	Pewter (cast)	23	—
Zinc Alloys, (CR)	70	10	Tin-Base Babbitts (chill cast)	22	5
Columbium, Ann	E80	—	Lead-Base Babbitts (chill cast)	21	7
Aluminum Brass, Ann	F77	—	White Metal (cast)	20	—
Admiralty Metal, Ann	F75	—	White Metal, Ann	17	—
Ingot Iron, Ann	69	—	Pewter, Ann	13	—
Magnesium Alloys (forged)	58	11	Hard Lead Alloys (chill cast)	11.2	4.2
Red & Semi-Red Brass, Cast Leaded	58	8	Hard Lead Alloys (extr)	8.7	3.7
Gold, CW	58	—	Hard Lead Alloys (rolled)	7.7	1.8
Magnesium Alloys (cast), Sol'n Tr	57	6	Grade A Tin, Ann	7	—
Zinc Alloys (HR)	56	5	Tellurium Lead (extr)	6	—
Tantalum, Ann	E60	—	Grade A Tin (as cast)	5.5	0.5
			Soft Lead (chill cast)	4.2	—

Hardness of Plastics and Rubber[a]

Material ↓	Average	Range, ±	Material ↓	Average	Range, ±
ROCKWELL HARDNESS			Acetal	R120	—
			Polyvinyl Chloride, Rigid	R118	2
Urea	M118	2	Polycarbonate	R118	—
Melamines	M117	8	Nylon 66	R118	—
Phenolics, GP	M114	6	Polytrifluorochloroethylene	R112	3
Phenolics (cast), Mech & Cml	M106	14	Nylons 6 & 610	R111	7
Phenolics, Shock & Ht Res	M106	14	Phenolics (cast), Transparent	R109	11
Allyls (cast)	M105	13	Cellulose Nitrate Sheet	R105	10
Phenolics, Elec	M105	5	Ethyl Cellulose	R95	25
Diallyl Phthalate	M104	4	Polypropylene	R90	5
Plastics Laminates	M98	23	Cellulose Acetates	R86	37
Phenolics (cast), Decorative	M97	8	Cellulose Propionate	R70	50
Epoxies (cast)	M92	13	Nylons, Soluble	R64	19
Acrylics	M91	12			
Polyesters (cast), Rigid	M90	25	DUROMETER HARDNESS		
Nylons, Glass Fiber-Filled	M90	5			
Silicone Plastics, GP	M89	—	Hard Rubber, High Ht Res	A89	3
Polystyrene, Glass Fiber-Filled	M85	5	Hard Rubber, Low Moisture Abs	A88	4
Polyvinyl Formal	M85	—	Hard Rubber, Cml Res	A87	3
Mod Polystyrenes, Ht & Cml Res	M83	5	Hard Rubber, GP	A82	5
Polymethylstyrenes	M79	4	Polyvinyl Chloride, Nonrigid	A75	25
Polystyrenes, GP	M75	10	Styrene-Butadiene Rubber	A65	25
Rubber Phenolics	M65	25	Natural Rubber	A60	30
Vinylidene Chloride	M57	8	Butyl Rubber	A60	20
Mod Polystyrenes, High Impact	M55	25	Polyvinyl Alcohol	A55	45
Silicone Plastics, High Impact	M45	—	Polyethylenes	D58	13

[a] In the first part of this table materials are listed in order of decreasing Rockwell hardness on two scales (M and R) which, though separated here, actually overlap to some indeterminate degree; in the second part of this table materials are listed in order of decreasing durometer hardness. No relationship between the two parts of the table is implied.

Creep Strength of Metals

Material ↓	Form, Condition	Stress (1000 psi) for 0.01% Creep per 1000 Hr at Indicated Temp (F)					Stress (1000 psi) for 0.1% Creep per 1000 Hr at Indicated Temp (F)				
Up to 800 F		300	400	500	600	800	300	400	500	600	800
NONFERROUS METALS											
Coppers	Wrought (annealed)	3–8	1.5–5	0.4–2.6	—	—	—	—	—	—	—
Nonleaded Brasses	Wrought (annealed)	0.9–19	2–11	0.3–23	—	—	25	5–9	1–2	—	—
Bronzes	Wrought (annealed)	14–23	5–10	2–5	—	—	—	—	—	—	—
Cupro-Nickel	Wrought (water quenched, aged)	25–40	15–30	8–30	—	—	—	22	13	—	—
Aluminum 2024-T	Sheet	52	44	—	—	—	—	—	—	—	—
Aluminum 7075-T	Sheet	50	30	—	—	—	—	—	—	—	—
Titanium (commercial)	Sheet (annealed)	—	38	—	32	10	—	—	—	—	—
Above 800 F		1000	1100	1200	1500	1600	1000	1100	1200	1500	1600
CARBON AND LOW ALLOY STEELS											
Low Carbon Steel	Wrought, Cast	1.8	—	0.1	—	—	3.3–5	—	0.5	—	—
Carbon-Molybdenum Steels	Wrought, Cast	5–7	3	1	—	—	10–12	4	2	—	—
Chromium-Molybdenum Steels (0.5–3%)	Wrought, Cast	6–12	2–4	1–2.5	—	—	10–20	3–8	2–4.5	—	—
Chromium Steels 4–6%	Wrought, Cast	6–7	2.5–3.5	1–2	—	—	8–11	5–6.5	2–3.5	—	—
6–10%	Wrought, Cast	5–9	2.5–4	1–2	—	—	8–12	4–6	2.5–3	—	—
STAINLESS STEELS											
Martensitic Chromium Steels (403, 410, 416, 420)	Wrought	8	3.5	1.3	—	—	9.2	4.2	2	—	—
Ferritic Chromium Steels (405, 430, 440)	Wrought	4.2–7	2.3–4.5	1.0–1.6	—	—	6–8.5	3–5	1.5–2.2	—	—
Nickel-Chromium Steels 304, 316, 321, 347	Wrought	12–17	7.5–11.5	4.5–7	1–2	—	17–25	12–18.2	7–12.7	1.2–2.8	—
309	Wrought	—	—	4	0.5	—	15.9	11.6	8	1.0	—
310, 314	Wrought	17	13	8	2	—	17	13–14	9	1–2.5	—
CORROSION RESISTANT CASTING ALLOYS											
Iron-Chromium Alloys (HC, HD)	Cast	—	—	—	—	—	—	—	—	1.2–3.5[a]	0.7–1.9
Iron-Chromium-Nickel Alloys (HE, HF, HH, HI, HK, HL)	Cast	—	—	—	—	—	—	—	—	3.5–7[a]	2–4.3
Nickel-Chromium Alloys (HT, HU, HW, HX)	Cast	—	—	—	—	—	—	—	—	6–8.5[a]	3–5
HIGH TEMPERATURE ALLOYS											
Inconel X		—	—	—	—	—	—	—	64	12.3	9.0
19-9 DL		—	—	—	—	—	—	—	20	7.1	—
Hastelloy X		—	—	—	—	—	—	—	—	—	2.4
N 155		—	—	—	—	—	—	—	18.4[b]	10.3	—
S-816		—	—	—	—	—	—	—	42	11.5	5.8

[a]At 1400 F. [b]At 1350 F.

Stress-Rupture Strength of Metals

Material ↓	Form, Condition	Stress (1000 psi) for Rupture in 100 Hr at Indicated Temp (F)					Stress (1000 psi) for Rupture in 1000 Hr at Indicated Temp (F)				
Up to 800 F		300	400	500	600	800	300	400	500	600	800
NONFERROUS METALS											
Coppers	Wrought (annealed)	22–25	20–24	—	—	—	19–21	15–19	—	—	—
Nonleaded Brasses	Wrought (annealed)	34–50	26–35	—	—	—	28–46	18–25	—	—	—
Bronzes	Wrought (annealed)	57	36	—	—	—	50	30	—	—	—
Aluminum Alloys											
2024–T	Sheet	—	—	—	—	—	37	19	—	—	—
7075–T	Sheet	—	—	—	—	—	20	9	—	—	—
Titanium (commercial)	Sheet (annealed)	—	45	—	—	20	—	44	—	32	16
Titanium Alloys											
4 Al–4 Mn		—	—	—	—	—	—	110	—	95	46
5 Al–2.5 Sn		—	—	—	—	—	—	76	—	65	58
8 Mn		—	—	—	—	—	—	100	—	91	26
Above 800 F		1000	1200	1400	1500	1600	1000	1200	1400	1500	1600
CARBON AND LOW ALLOY STEELS											
Low Carbon Steel	Wrought, Cast	15	5	1.5	—	—	10	2.8	0.7	—	—
Carbon–Molybdenum Steel (0.5% Mo)	Wrought	32–37	8	—	—	—	—	—	—	—	—
Chromium–Molybdenum Steels (0.5–3%)	Wrought	28–40	10–13	—	—	—	24–39	4–8	0.5–1.0	—	—
Chromium Steels											
4–6%	Wrought	23–30	4–9	2–3	1.5–2	—	18–20	5–7	1.8–2	0.7–1	—
6–10%	Wrought	—	10	3	2	—	—	6	2	1	—
STAINLESS STEELS											
Martensitic Chromium Steels (403, 410, 416, 420)	Wrought	—	—	—	—	—	13[a]	3[a]	—	—	—
Ferritic Chromium Steels (405, 430, 446)	Wrought	—	—	—	—	—	13[a]	3[a]	—	—	—
Nickel–Chromium Steels											
304, 316, 321, 347	Wrought	48–55	22–29	—	6–7	—	38–40	18–22	—	3.8–4.4	—
309	Wrought	—	28	—	8.5	—	—	20	—	4.8	—
310, 314	Wrought	38	28	—	11	—	30	18	—	5	—
CORROSION RESISTANT CASTING ALLOYS											
Iron–Chromium Alloys (HC, HD)	Cast	—	—	3–10	—	1.5–5	—	—	2	—	1.2
Iron–Chromium–Nickel Alloys (HE, HF, HH, HI, HK, HL)	Cast	—	30–35	10–15	—	5–9	—	17–22	8–10	—	3.5–5
Nickel–Chromium Alloys (HT, HU, HW, HX)	Cast	—	—	10–18	—	6–8.5	—	—	7.5–12.5	—	4–7
HIGH TEMPERATURE ALLOYS											
Inconel X		115	80	42	30	11	110	55	33	18.5	6.6
19–9 DL		—	60	28	13	—	—	40	16.5	10.5	—
Hastelloy C		—	53	—	15	—	—	35	—	9.5	—
Hastelloy X		—	45	21	14	8	—	30	16	10	6
N–155		—	60	25.7	20	15	—	46	19.5	15	—
S–816		—	62	32	29	15	—	50	27	22	10
L605		—	45	30	22	15	—	—	23	18	11

[a] 10,000 hr.

Effect of Radiation on Metals

EFFECT ON HARDNESS

Material			Radiation Exposure[a]	Change in Brinell Hardness
Type	Condition	Initial Brinell Hardness		
CARBON STEELS				
1018	Annealed	174	1	+9
		156		+12
	Hardened	241	1	+6
	Annealed	138	2	+23
	Hardened	237		+6
1042	Annealed	201	1	+6
		236		+34
	Hardened	430	1	+14
	Annealed	225	2	−38[b]
	Hardened	390		+36
1045	Annealed	187	3	0
	Hardened	514		−144[c]
1095	Annealed	297	1	+14
	Hardened	542		+8
	Annealed	290	2	+25
	Hardened	535		0
1113	Annealed	195	1	+22
	Hardened	190		+5
1141	Annealed	220	1	+35
	Hardened	421		+9
STAINLESS STEELS				
304	Annealed	131	4	0
	Malcomized	654	5	+156
309	Annealed	152	4	+6
316	Annealed	143	4	0
	Annealed	154	5	+74
	Cold Worked	226		+59
329	Annealed	158	6	0
347	Annealed	152	4	0
	Annealed	183	6	0
	Malcomized	656	7	0
347 (Cb+Ta)	Annealed	153	6	+22
	Shot Peened	153		+15
410	Malcomized	656	5	+84
		688	7	0
		739	8	0
431	Annealed	277	6	+54
	Hardened	371		+29
440C	Hardened	545	5	0
		461	8	+73
		388		+27
	Malcomized	577	7	+223
442	Annealed	185	6	+38
	Hardened	200		+50
17-4PH	Annealed	315	6	+162
	Hardened	415	6	+35
		403	9	+29
		477		0
	Malcomized	740	6	+80
NICKEL AND ITS ALLOYS				
Nickel A	Annealed	64	10	+73
Hastelloy C	Cast	228	11	+132
		170		+58
	Wrought	255	10	+30
		209	12	0
		256	13	+19
Monel	Annealed	150	12	+59
		157	13	+23
K Monel	As Received	260	12	+25
		255	13	+10
	Annealed	148	6	+32
	Hardened	341		0
Inconel	As Received	175	12	+65
		180	13	+48
Inconel X	Annealed	209	12	+56
		219	13	+28

[a] 1 = nvt (integrated thermal flux-product of flux and exposure time) of 1 x 10^{19} slow at 450-500 F.
2 = nvt of 2 x 10^{19} slow and 7 x 10^{18} fast at 70-140 F
3 = nvt of 3 x 10^{20} slow and 1 x 10^{20} fast at 70-80 F.
4 = nvt of 1.2 x 10^{19} slow in 400-500 F flewing water.
5 = nvt of 3.7 x 10^{20} slow and 5.1 x 10^{20} fast at 70-80 F.
6 = nvt of 3 x 10^{19} slow in 540 F flowing water.
7 = nvt of 10^{19} slow; dry exposure.
8 = nvt of 5 x 10^{19} slow and 4 x 10^{19} fast.
9 = nvt of 4.4 x 10^{19} slow in 540 F flowing water.
10 = nvt of 1 x 10^{19} slow in 400-500 F flowing water.
11 = nvt of 4 x 10^{19} slow and 5 x 10^{19} fast.
12 = nvt of 5 x 10^{19} slow and 4 x 10^{19} fast at 70-140 F.
13 = nvt of 4 x 10^{19} slow in 540 F flowing water.

[b] No explanation for decrease in hardness values.

[c] Decrease in hardness due to corrosion products caused by leaking container.

EFFECT ON TENSILE PROPERTIES

Material				Radiation Exposure[a]	Chg in Properties After Irradiation	
Type	Condition	Ten Str, 1000 psi	Elong (2 in.), %		Ten Str, 1000 psi	Elong, %
STAINLESS STEELS						
304	Annealed [b]	92	71	1	+1	−21
309	Annealed [b]	95	54	1	+4	−3
316	Annealed [b]	90	70	1	−1	−3
347	Annealed [b]	99	56	1	+4	−2
316	Annealed [c]	79	—	2	+71	—
410	Malcomized [c]	69	—	3	+3	—
440C	Hardened [c]	205	—	3	+35	—
NICKEL AND ITS ALLOYS						
Nickel	Wrought [b]	65	45	1	+4	−11
Monel	As Received	129 [d]	—	4	+4	—
		86 [e]	32		+5	−3
		85 [e]	33	5	+11	−23
K Monel	As Received	210 [d]	—	4	−15	—
		125 [e]	10		+8	+9
		211 [d]	—	5	+15	—
		123 [e]	11		+11	−8
Inconel	As Received	150 [d]	—	4	+10	—
		107 [e]	30		+6	−1
		151 [d]	—	5	+21	—
		106 [e]	31		+10	−2
Inconel X	As Received	174 [d]	—	4	+24	—
		128 [e]	36		+11	−1
		174 [d]	—	5	+29	—
		126 [e]	37		+7	−14
	Cast [e]	80	—	3	+27	—
Hastelloy C	Wrought	139 [b]	53	1	+3	−11
		198 [d]	—	4	−7	—
		140 [e]	20	4	−3	+16
		138 [e]	20	5	+4	−8
		198 [d]	—		+22	—
HIGH DENSITY MATERIALS						
Tantalloy	As Received	136	29	6	+29	−15
Tungsten		152	0	6	−35	0
Tantalum		68	21	6	+18	−4
Tantung G		72	5	6	−3	−1

[a] 1 = nvt of 1 x 10^{19} slow in 400-500 F flowing water.
2 = nvt of 3.7 x 10^{20} slow and 5.1 x 10^{20} fast at 70-80 F.
3 = nvt of 4 x 10^{19} fast.
4 = nvt of 4 x 10^{19} slow in 540 F flowing water.
5 = nvt of 5 x 10^{19} slow and 4 x 10^{19} fast in cooling water at 70-140 F.
6 = nvt of 1 x 10^{19} slow and 5 x 10^{19} fast (estimated).
[b] Flat specimens. [c] Subsize round specimens. [d] Notched specimens.
[e] Unnotched specimens.

EFFECT ON DENSITY[a]

Material		Avg Chg in Density After Irradiation, %
Type	Initial Density, lb/in.	
Stainless Steels		
316	7.995	−0.06
347	7.938	−0.09
347+Ta	7.942	−0.04
410	7.675	−0.05
Nickel A	8.894	−0.07
Monel	8.836	−0.05
Cobalt Alloys		
Stellite 3	8.550	+0.06
Stellite 6	8.330	+0.11
Carbon Steel (SA-212)	7.850	0

[a] Radiation exposure: nvt of 2 x 10^{20} slow and 3.5 x 10^{19} fast at 70-140 F.

EFFECT ON ELECTRICAL RESISTIVITY

Material		Avg Chg in Elec Res After Irradiation
Type	Initial Elec Res	
Stainless Steels		
304	80 (28.0 C)	+0.2 (27.8 C)
309	79 (27.5 C)	−2.1 (27.0 C)
316	77 (28.4 C)	+1.01 (28.4 C)
347	75 (26.2 C)	+0.44 (27.3 C)
Nickel A	9 (27.0 C)	−0.17 (27.2 C)
Hastelloy C	126 (26.2 C)	+7.30 (27.8 C)

Sources of Data

Many of these compilations are entirely new. Others have been published previously in this magazine, particularly in the 1957-58 *Materials Selector*. Most of the older compilations have been revised to a greater or lesser extent. Collecting new data and up-dating old compilations required the aid of many individuals and organizations. We gratefully acknowledge their assistance. Although it would be impractical to list all who contributed in one way or another, we acknowledge particularly the assistance of the following:

Acme Steel Co.
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American Lava Corp.
American Metal Climax, Inc.
American Smelting and Refining Co.
American Society for Testing Materials
American Welding Society
Battelle Memorial Inst.
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Vanadium-Alloys Steel Co.
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Corrections and additions: In compiling a data section of this nature it is impossible to avoid errors. Also, space limitations prohibited us from making this section as complete as we wish to make it. We will welcome your corrections and additions for future editions. Please address Data Editor, MATERIALS IN DESIGN ENGINEERING, *430 Park Ave., New York 22, N. Y.*

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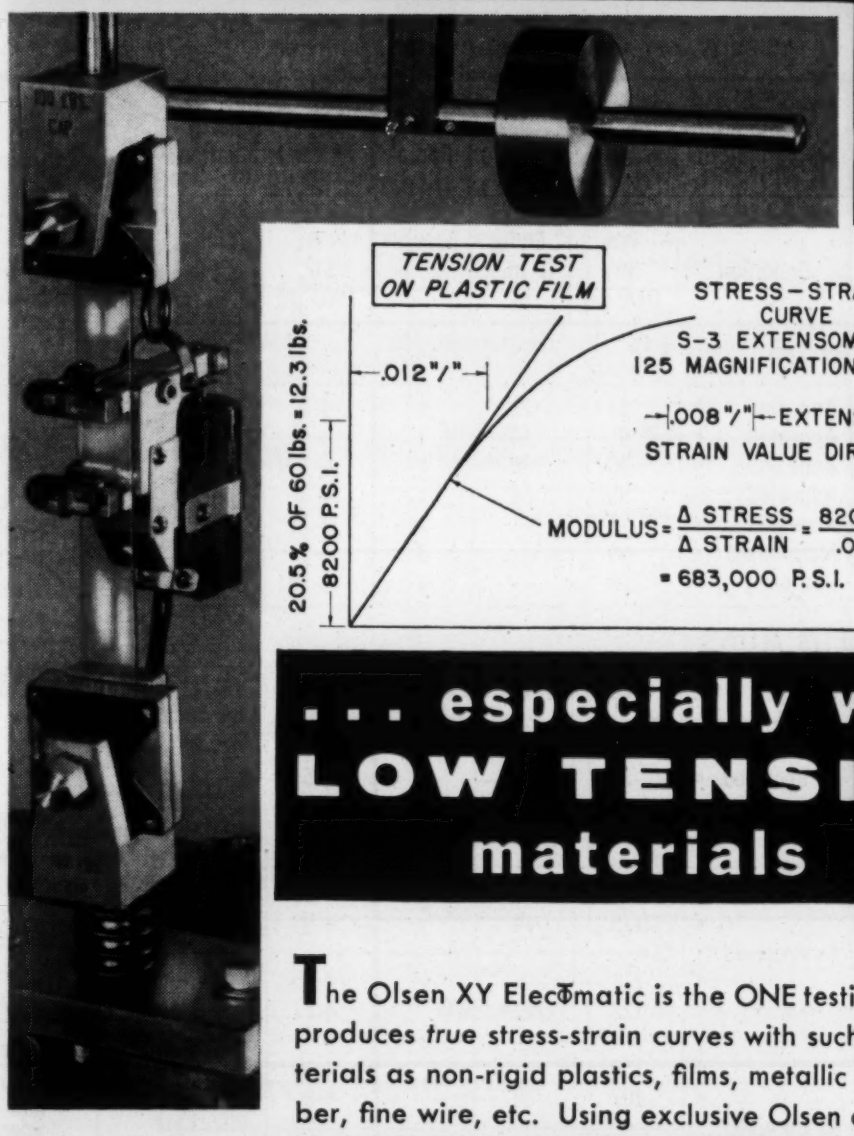

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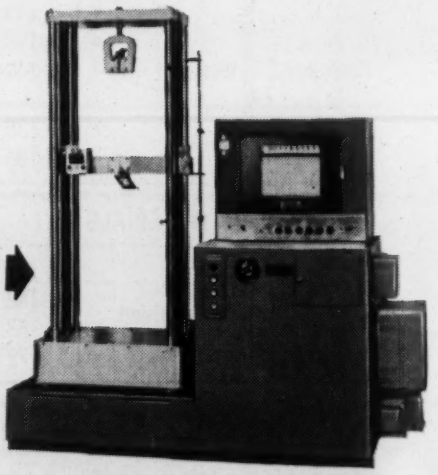

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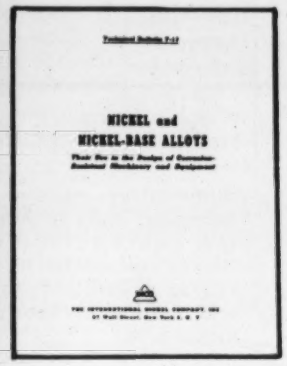
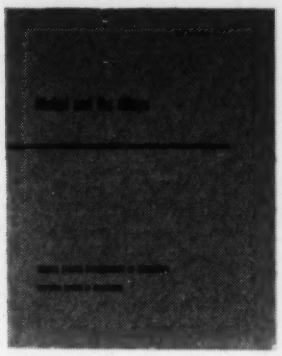


Nickel and Nickel-Base Alloys
(40 pages, cat. #T-13)

Discusses applications of various nickel alloys for construction of corrosion-resisting equipment. Gives chemical compositions, data on physical constants, mechanical properties, corrosion resistance.



Nickel and Its Alloys
(88 pages, cat. #250A)

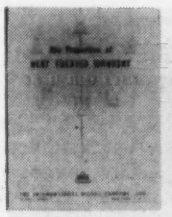
Reviews information about the occurrence, recovery and refining of nickel ores, and the properties and uses of high-purity and commercial forms of Nickel. Gives properties and industrial applications of important nickel-containing alloys. (Published by National Bureau of Standards, U. S. Dept. of Commerce.)

Stainless Steel in Product Design
(40 pages, cat. #204A)

It gives useful engineering data on the fabrication, mechanical, heat-resisting and corrosion-resisting properties of stainless steels. Illustrations show applications.

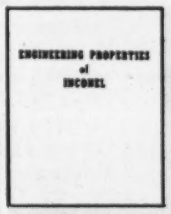
Engineering Properties of Monel and "R" Monel
(31 pages, cat. #T-5)

Gives physical constants, minimum mechanical properties in standard forms and sizes, data on its resistance to acids, salts, alkalies and organic substances.



The Properties of Heat-Treated Wrought Nickel Alloy Steels
(28 pages, cat. #51A)

Contains new data, largely in the form of charts, on the properties of the more commonly used engineering steels containing up to 5% Nickel.

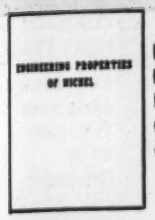


Engineering Properties of Inconel
(23 pages, cat. #T-7)

Gives composition, physical constants, and mechanical properties of heat-resisting Inconel. Discusses corrosion-resistance, working characteristics, and effect of temperature.

Nickel Alloy Steel Castings in Industry
(32 pages, cat. #52)

Data, classified by industrial fields, on properties and applications of cast nickel steels of the constructional grades.



Engineering Properties of Nickel
(23 pages, cat. #T-15)

Contains technical data on wrought and cast Nickel—its physical constants, mechanical properties, resistance to corrosion.

Engineering Properties and Applications of "Ni-Vee" Bronzes
(28 pages, cat. #207A)

This new booklet describes the advantages that the five Ni-Vee nickel-tin bronzes offer as constructional parts, pressure castings and bearings.

Engineering Properties of "K" Monel and "KR" Monel
(27 pages, cat. #T-9)

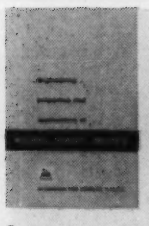
Gives data on these heat-treatable alloys which combine high corrosion-resistance with the strength of alloy steel. Has detailed information on physical constants, mechanical properties.

Nickel-Aluminum Bronze
(12 pages, cat. #133A)

Describes properties of aluminum bronzes containing Nickel additions up to 5%. Nickel contributes strength plus resistance to corrosion, heat and wear.

Engineering Properties of Duranickel
(22 pages, cat. #T-32)

Has data on this age-hardenable nickel-aluminum alloy which combines corrosion - resistance with the high hardness and strength ordinarily formed in heat-treated alloy steels.

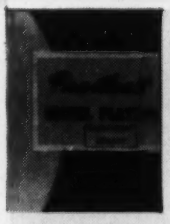


Engineering Properties and Applications of Nickel Cast Irons
(28 pages, cat. #69A)

Presents the many valuable characteristics of modern alloyed cast irons and illustrates their broad acceptance throughout industry.

Standard Alloys for Special Problems
(16 pages, cat. #2-B)

Catalogs 18 Inco Nickel Alloys in problem-solving sections to facilitate selection of most suitable alloy for specific service conditions.

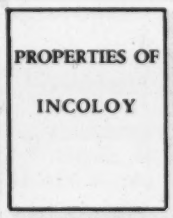


Practical Nickel Plating
(44 pages, cat. #77A)

Presents a technical source of information on the various concepts of nickel plating with emphasis on the industrial phases.

Some Properties of Inco Nickel Alloys at Low Temperatures
(6 pages, cat. #120-B)

Describes the properties, mechanical and physical, of various wrought and cast high-nickel alloys when exposed to sub-zero temperatures.



Properties of Incoloy
(7 pages, cat. #99-B)

Gives latest data on composition, heat treating, machining and welding, and comparative facts about new Inco Nickel Alloy for high-temperature use.

Standard Alloys for special problems in designing equipment to withstand destructive service conditions

LITERATURE ON APPLICATIONS

AERONAUTICAL

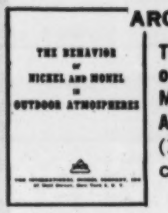
High Temperatures Spur Use of Nickel-Base Alloys
(8 pages, cat. #254A)

Summarizes properties and applications of new nickel-base alloys developed specifically for aeronautical and other high-temperature uses.

AGRICULTURAL

Nickel-Containing Materials in Tractors and Farm Implements
(32 pages, cat. #2A)

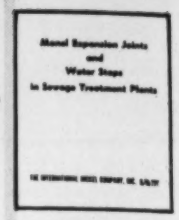
This paper deals with the properties of nickel alloy steels and cast irons, including ductile cast iron, and their advantages for farm and garden construction.



ARCHITECTURAL

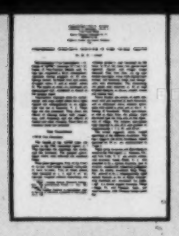
The Behavior of Nickel and Monel in Outdoor Atmospheres
(10 pages, cat. #T-30)

Summarizes results of corrosion tests in America and England on Nickel and Monel in rural, suburban, industrial and marine outdoor atmospheres.



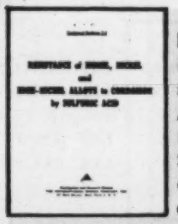
Monel Expansion Joints and Water Stops in Sewage Treatment Plants
(2 pages, cat. #125-B)

Summarizes construction and installation of Monel expansion joints, construction joints and water stops in the New York Bowery Bay Sewage Treatment Plant.



Atmospheric Corrosion Behavior of Some Nickel Alloys
(20 pages, cat. #211-A)

Presents the results of 20 year atmospheric corrosion tests on Nickel and Monel nickel-copper alloy conducted by ASTM.

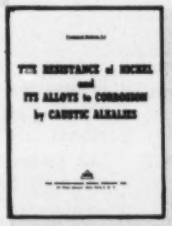


Resistance of Monel, Nickel and High-Nickel Alloys to Corrosion by Sulfuric Acid
(44 pages, cat. #T-3)

Discusses factors affecting corrosion rate of Nickel and alloys in sulfuric acid, including acid concentration, temperature, aeration, velocity, film formation and presence of oxidizing salts.

Corrosion-Resisting Characteristics of Iron Modified "90-10" Cupro-Nickel Alloy
(20 pages, cat. #170-A)

Summary of information on the corrosion-resisting characteristics of iron modified "90-10" cupro-nickel alloy in sea water.



The Resistance of Nickel and Its Alloys to Corrosion by Caustic Alkalies
(23 pages, cat. #T-6)

Discusses resistance of Nickel, Monel and other nickel alloys including nickel cast iron to corrosion by caustic soda. Contains service records.

Corrosion-Resistance of Cupro-Nickel Alloys Containing 10 to 30% Nickel
(12 pages, cat. #190-A)

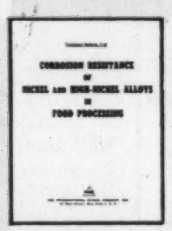
Corrosion data gathered as the result of many tests on cupro-nickel alloys under stress and exposed to different corrosive environments.

Nickel-Containing Alloys for Permanent Magnets
(16 pages, cat. #16-A)

Describes recent progress in permanent magnet alloys. Characteristics of the Alnico series of iron-nickel-aluminum alloys are treated in detail. Other permanent magnet alloys, too.

Design of Nickel Magneto-striction Transducers
(44 pages, cat. #209-A)

This book was prepared to aid engineers in designing magnetostriction transducers to meet their particular needs for operation at frequencies up to about 100,000 cycles.



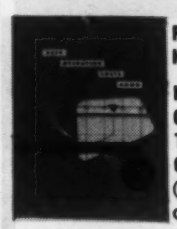
FOOD PROCESSING

Corrosion-Resistance of Nickel and High Nickel Alloys in Food Processing
(35 pages, cat. #T-28)

Presents results of studies made to determine and compare suitability of various materials for equipment used in food processing.

Heat Transfer Through Metallic Walls
(24 pages, cat. #23-B)

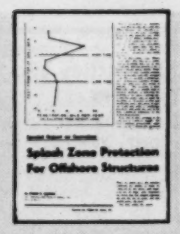
Tells how to properly estimate overall heat transfer rates through metallic walls. Includes formulae for determining heat transfer rates.



FURNACE AND HEAT-TREATING

Keep Operating Costs Down When Temperatures Go Up
(18 pages, cat. #55-B)

Describes how Inconel helps cut production costs at temperatures up to 2200°F. Cites case histories.



PETROLEUM

Splash Zone Protection For Offshore Structures
(4 pages, cat. #134-B)

Analyzes the problem of protecting offshore structures from corrosion with particular attention to the critical splash zone. Discusses corrosion rates of various metals.

The Basis for Selecting Alloy Cast Irons for the Petroleum Industry
(8 pages, cat. #34-A)

Deals with the wide range of properties available through alloy cast irons and special service types of alloy irons.

Some Corrosion Problems in Petroleum Refineries
(7 pages, cat. #67-B)

Analyzes 15 actual problems concerning corrosion of refinery equipment. Contains quantitative information.

The Selection of Materials for Some Petroleum Refinery Applications
(8 pages, cat. #122-B)

Summarizes investigations made in a number of refineries to determine the best materials for resistance to corrosion.

PICKLING

5-Way Savings in Pickling
(6 pages, cat. #74-B)

Case records show how Monel pickling equipment has given longer service, made possible greater payloads and increased safety in typical pickling operations.

Experience in every major industry materials and alloys provide many

Finding the Most Suitable Metal

It would be easy to select a metal for a job if you had to consider only one property. But it seldom works out that way when you need a metal to withstand some unusually destructive combination of conditions.

Usually you must search for the metal with the most suitable combination of essential properties.

Very often you can find this combination ready-made among the many nickel alloys.

To help you get a general idea of the many useful and often unusual properties which are available in these alloys, we have listed a few of the nearly 400 publications which are available for your use in finding the alloy most suited to your needs.

Technical Service on Metal Problems

Even if you do not find the ready-made answer you are looking for among these publications, there is a good chance Inco's Technical Service can help you. There is never any obligation for this service.

If, for example, you are confronted with a corrosion problem, our Corrosion Engineering Service will

INCO NICKEL MAKES ALLOYS PERFORM

AUTOMOTIVE

Brake Drum Materials
(24 pages, cat. #7A)

Discusses, from the standpoints of physics and metallurgy, the problems involved in selecting a material for decelerating a vehicle.

BRIDGES

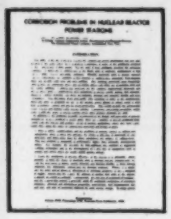
Nickel Steels and Other Nickel Alloys in Bridge Construction
(36 pages, cat. #179A)

Describes past and present uses of nickel structural steels and low-alloy high strength steels in bridge construction to eliminate dead weight.

CASTINGS

Cast to Outlast
(15 pages, cat. #104-B)

Case-history booklet describes many service problems solved by use of Inco sand and centrifugal castings. Also how manufacturers can cut costs on small parts.



CORROSION

Corrosion Problems in Nuclear Reactor Power Stations
(16 pages, (cat. #232-A)

Deals with corrosion of constructional materials in nuclear power plants where water serves both as a primary coolant and for steam generation.

Nickel, Monel, Inconel . . . their contribution to chemical engineering
(49 pages, cat. #45-B)

Appraises Nickel, Monel, Inconel, and their application in the chemical industry. Describes reaction of these materials to specific products and reagents.

Victory Over Bromine
(7 pages, cat. #49-B)

Reports results of corrosion and impact tests that led to acceptance by Interstate Commerce Commission of new Monel drum for shipping bromine.

Handling Fluorine and Fluorine Compounds with Inco Nickel Alloys
(24 pages, cat. #141-B)

Gives corrosion data on Fluorine and Hydrofluoric acid and summarizes case history data on solutions of corrosion problems in many industries.

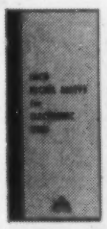
Corrosion and the Final Choice
(11 pages, cat. #25-B)

Describes the principal factors that should be considered in the final choice of a corrosion-resisting material.

ELECTRICAL & ELECTRONICS

Iron-Nickel Alloys for Magnetic Purposes
(20 pages, cat. #14-A)

Approximate compositions and major special properties of the most important of the iron-nickel base, magnetically soft alloys.



Inco Nickel Alloys for Electronic Uses
(28 pages, cat. #51-B)

Details information on 13 Inco Nickel Alloys used in electronic, radio, electrical industries. Gives composition, general characteristics, typical uses, available mill forms.

GLASS

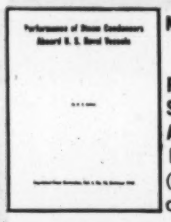
Metallurgical Analysis of Glass Mold Cast Irons
(10 pages, cat. #25-A)

Ten essentials of glass mold castings and typical compositions required.

MACHINE TOOLS

The Role of Nickel in the Machine Tool Industry
(32 pages, cat. #46-A)

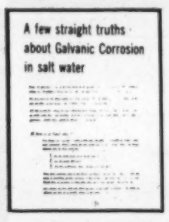
Covers selection of materials for vital machine tool components subjected to wear, stress and shock, giving detailed information on mechanical properties.



MARINE

Performance of Steam Condensers Aboard U.S. Naval Vessels
(8 pages, cat. #26-A)

Details on the excellent service rendered by "70-30" cupro-nickel tubes employed in the construction of all types of heat exchangers.



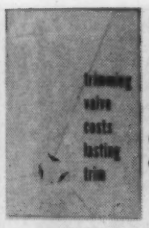
A Few Straight Truths About Galvanic Corrosion in Salt Water
(4 pages, cat: #64-B)

Tells how to identify galvanic corrosion, foretell if it is serious, take precautions to reduce it.

MINING

Alloy Steel Churn Drill Bits Prove Superior in Tough Ground
(4 pages, cat. #30-A)

Results of tests that proved 4340 type nickel-chromium - molybdenum steel was superior to carbon steel and the most satisfactory of a group of steels tested.



POWER

Trimming Valve Costs with Lasting Trim
(8 pages, cat. #77-B)

Shows how valve manufacturers use Inco Nickel Alloys for longer life where valves and trim meet special problems of corrosion.

Alloys for Heat Exchange Problems in Modern Power Plants
(28 pages, cat. #205-A)

Tubing problems and their solutions in main steam condensers, evaporators, feedwater heaters, and miscellaneous heat exchange applications.

PULP AND PAPER

Practical Solutions for Metal Problems in Pulp and Paper Mills
(33 pages, cat. #80-B)

Shows how mill operators have solved typical problems of corrosion, sliming, fatigue and wear. Describes the applications of Nickel and high-nickel alloys.

RAILWAY

Nickel Alloys in Railroad Equipment
(32 pages, cat. #36-A)

Covers diesel-electric, gas turbine, steam and electric locomotives, passenger equipment, freight cars and miscellaneous railroad applications.

SPRINGS

Alloy Spring Steels
(20 pages, cat. #41-A)

A discussion of the requirements for hot-formed springs and the comparative merits of various spring steels.

proves that Nickel-containing useful combinations of properties

study it, make tests where necessary, and suggest a practical solution.

If, on the other hand, you want to find a metal capable of withstanding high temperature, our High Temperature Engineering Service is ready to help you with your problem.

Or you may require technical assistance on the fabrication or mechanical application of a metal. Our Technical Service staff will assemble the facts you need and work with you in your plant to help secure the desired results.

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TECHNICAL FIELD SECTIONS

Information on the properties of nickel-containing alloys such as stainless and alloy steels, high nickel alloys, cast irons, non-ferrous alloys, nickel plating and other products is available to you through these members of the Development and Research staffs.

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Tel. Richmond 9-2496
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WESTERN CANADA
International Nickel Research & Technical Services, Ltd.
Elks Building, Calgary, Alta.
Tel. Amherst 9-2451

CENTRAL CANADA
The International Nickel Company of Canada, Ltd.
55 Yonge Street, Toronto 1, Ont.
Tel. Empire 4-7471

EASTERN CANADA
International Nickel Research & Technical Services, Ltd.
Room 808-9
Dominion Square Building, Montreal, Quebec
Tel. University 1-2030

SALES, STOCK and SERVICE CENTERS

These suppliers, through years of experience, are qualified to give you information and meet your requirements for Nickel and standard Inco Nickel Alloys out of warehouse stocks or through mill shipments. Through casting specialists, they are also prepared to offer technical service on the production of ferrous and non-ferrous castings containing Nickel.

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Whitehead Metal Products Company, Inc.
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Metal Goods Corporation
Tel. Dickens 8-5761

BEAUMONT 1, TEXAS
Metal Goods Corporation
Tel. Terminal 3-7536

BIRMINGHAM, ALABAMA
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Williams and Company, Inc.
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TULSA 3, OKLA.
Metal Goods Corporation
Tel. Gibson 7-4101

WINDSOR, CONN.
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Wilkinson Company, Ltd.
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Robert W. Bartram, Limited
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Inco Nickel Alloys Standard Mill Forms and Castings are sold under the following trademarks

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Inco-Hard "1"* electrode

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INCO

Properties of Materials

	PAGE
a. Irons and Steels	31
b. Nonferrous Metals	83
c. Plastics and Rubber	141
d. Nonmetallics (except Plastics and Rubber)	227
e. Finishes and Coatings	257

What the Data Mean:

With the exception of Section 2e, the Properties of Materials sections consist entirely of tabular data on the properties, forms and uses of engineering materials.

Tabular data on properties generally represent average test results obtained from many different sources and suppliers. Although the values may have been obtained from standard specified tests, in no case do the values represent minimum or maximum specified limits. A range of values may indicate either the normal variation encountered in that particular test, or the differences attributable to variations in the composition, temper, heat treatment, form or other condition of the material. Where a value or range applies only to a particular condition of the material, the condition is stated. Unless otherwise indicated, properties of metals apply to wrought forms and properties of nonmetallics apply to molded forms.

Available forms listed in these sections are the most important forms that are readily available commercially. Uses listed in these sections are only typical and are not intended to be exhaustive.

These data have a limited purpose. Space does not permit a complete description of the materials and test conditions to which the data apply; hence, these data cannot be used directly for final designs. They are intended solely to aid in the important job of materials selection.

SUPPLIERS' LITERATURE

Irons and Steels

Alloyed Gray Iron. Advance Foundry Co., 14 pp, illus. Use of a chromium-molybdenum alloyed gray iron called Strenes for drawing, forming, blanking and roller dies used in producing automotive parts. **1**

Flat Rolled Steel. Alan Wood Steel Co., 8 pp, illus., No. D-39. Describes low alloy, high strength, flat rolled steel available in strip, coils, cut lengths and sheared plate in varying thicknesses. **2**

Pearlitic Malleable Iron. Albion Malleable Iron Co., 23 pp, illus. Information on metallurgical characteristics of pearlitic malleable iron. **3**

Literature on Steel. Allegheny Ludlum Steel Corp., 8 pp. List of company bulletins covering selection, fabrication and use of stainless and heat resistant steels, tool and die steels and electrical steels. **4**

Molybdenum-Iron Castings. American Metal Climax Inc., Climax Molybdenum Div., 24 pp, illus. Series of bulletins explaining the use of molybdenum in gray and malleable iron. Gives properties, uses and fabrication data for molybdenum-iron castings. **5**

Prefinished Metals. American Nickeloid Co., 24 pp, illus. Fabrication, uses and properties of prefinished metals. **6**

Cold Extruded Steel. American Radiator & Standard Sanitary Co., 16 pp, illus. How low carbon steel parts are cold extruded and fabricated in one piece without machining. **7**

Steel Strip. American Steel & Wire Co., Div. of U.S. Steel Corp., 48 pp, illus. Physical properties, dimensions, tempers and finishes of cold rolled stainless and carbon steel strip. **8**

Aluminized Steel. Armco Steel Corp., 22 pp, illus. Corrosion resistance, mechanical properties, fire resistance and heat reflectivity of aluminized steel. Gives sizes, gages and available forms. **9**

High Temperature Springs. Associated Spring Corp., 8 pp, illus., No. 17. Information on how to design and select materials for springs that must operate at high temperatures. **10**

Alloy Steels. Bethlehem Steel Co., 36 pp, illus., No. 415-A. Outlines individual effects of nickel, chromium, molybdenum, vanadium, manganese, silicon, copper, boron and aluminum as alloying elements for steel. **11**

Bar Steels, Bliss & Laughlin, Inc., 4 pp, illus., No. 55. How Strain-Tempered bar steel improves such machinery parts as gears. **12**

Tool Die Steels. Cannon-Muskegon, Inc., 13 pp, No. 27. Composition, physical properties and heat treating of various tool and special purpose steels. **13**

Magnetic, Electrical Alloys. Carpenter Steel Co., 65 pp, illus. Chemical composition, magnetic properties, heat treatment, corrosion resistance and mechanical properties of iron-nickel alloys for electronic, magnetic and electrical devices. **14**

Composite Metal. Chicago Bridge & Iron Co., 32 pp, illus. Strength, ductility, uses, and design information for a composite metal called "Horton-clad." **15**

Chromized Steel. Chromalloy Corp., 4 pp, illus., No. 25. Heat resistance, characteristics, workability and cost of a chromized sheet steel material. Gives typical applications. **16**

Enameled Metal Strip. Coated Coil Corp., 4 pp, illus. Describes coiled enameled metal strip supplied in widths up to 30 in. **17**

Leaded Steels. Copperweld Steel Co., Steel Div., 16 pp, illus. Mechanical properties and workability of leaded steels. **18**

Stainless Steel. Superior Steel Div., Copperweld Steel Co., 8 pp, illus. Chemical composition and corrosion resistance data on a boron stainless steel for reactor shielding. **19**

Specialty Steels. Crucible Steel Co. of America, 12 pp, illus. Use of specialty alloy, carbon, tool and stainless steels in heavy construction and mining machinery parts. **20**

Alloy Steel Wire. Wilbur B. Driver Co., 4 pp, illus. Shows facilities of company for vacuum melting, annealing, pickling and drawing alloy steel wire. **21**

Stainless Steel. Eastern Stainless Steel Corp., 4 pp, illus. Describes type 321 SW grade of sheet and plate resulting from new method of melting ingots. **22**

Purchasing Steel Strip. Edgcomb Steel & Aluminum Corp., 20 pp, illus. Information on a steel strip purchasing plan that cuts costs, reduces lead-time and insures continuity of supply. **23**

Stainless Steel. Electric Steel Foundry Co., 12 pp, illus., No. 5. Mechanical properties of cast and wrought stainless steels after heat treatments at temperatures from 800 to 1200 F. **24**

Stainless Steel. Peter A. Frasse & Co., Inc., 2 pp, No. 2. Chemical composition of stainless steel bar, forgings, plate, sheet, strip, pipe and tubing to meet Air Force, Navy Aeronautical and Federal specifications. **25**

Gray Iron Specs. Gray Iron Founders' Society, 4 pp. Summary of specifications for gray cast irons and ductile (nodular) cast irons. Includes mechanical properties, chemical composition and methods of testing. **26**

Carbon Specialty Steels. Green River Steel Corp., 4 pp, illus. Describes a process for making steels of unusual densities and fine grain structure. **27**

Stainless Steels. International Nickel Co., Inc., 8 pp, illus. Mechanical and physical properties of 200 series stainless steels, plus fabricating data. **28**

Stainless Steels. Jones & Laughlin Steel Corp., Stainless Steel Div., 12 pp, illus. Chemical composition, uses, corrosion resistance. physical and mechanical properties, machinability and weldability of 17 types of stainless steels. **29**

High Temperature Alloy. Utica Metals Div., Kelsey-Hayes Co., 16 pp, illus. Composition, uses, physical properties, heat treatment and machining of Udimet 500, a nickel-base high temperature alloy. **30**

Steel Bars. La Salle Steel Co., 24 pp, illus. Design information, properties, uses and tool life for "Fatigue-Proof" steel bars. **31**

Wear Resistant Steel. Latrobe Steel Co., 20 pp, illus. Diagrams show exact shape and size of parts made of a wear resistant steel for use in sandblasting equipment. **32**

Clad Steels. Lukens Steel Co., 32 pp, illus. Mechanical and chemical properties, sizes, uses, design information and fabrication data for a series of nickel, stainless steel, Inconel and monel-clad steels. **33**

Manganese Steel. Manganese Steel Forge Co., 12 pp, illus. Chemical composition, design information and uses of rolled and forged high manganese steel. **34**

Zinc-Coated Steel. Weirton Steel Co. Div., National Steel Corp., 8 pp, illus. Advantages, uses and properties of zinc-coated steel sheets. **35**

Coated Steel Strip. Thomas Strip Div., Pittsburgh Steel Co., 20 pp, illus. Contains actual samples of strip steel electrolytically coated with zinc, copper, brass, lead alloy, nickel and chromium, in natural and buffed finishes. **36**

Iron Powder. Pyron Corp., 8 pp, No. 1. Technical information on hydrogen-reduced and electroytic iron powders. **37**

Stainless Steel. Republic Steel Corp., 40 pp, illus., No. 590a. Infofmation on cold forming, machining, forging, annealing, pickling, grinding and painting stainless steel. Charts give chemical composition and properties of the 300 and 400 series. **38**

Hot Rolled Steels. Joseph T. Ryerson & Son, Inc., 4 pp, illus., No. 11-2. Specifications and size ranges for hot rolled steel bars, structurals, plates, sheets and strip. **39**

Spring Steels. Sandvik Steel, Inc., 6 pp, illus. Sizes, materials and chemical composition of spring and specialty strip steels. **40**

Zinc-Coated Steel. Sharon Steel Corp., 12 pp, illus. Welding, soldering, cold forming, cleaning and storage of Galvanite zinc-coated steel. **41**

Cast Irons. Sorbo-Mat Process Engineers, 18 pp, illus. Specifications, grain structure, mechanical and physical properties, and uses of alloyed and plain cast irons. **42**

Steels. Timken Roller Bearing Co., Steel & Tube Div., Canton, Ohio. Complete catalog on steels. Write on company letterhead directly to Timken.

Constructional Steel. United States Steel Corp., 4 pp. Chemical composition and mechanical properties of T1, a low carbon, quenched and tempered constructional alloy steel. **43**

Chromium Steels. Universal-Cyclops Steel Corp., illus. Physical properties, chemical composition and room and elevated temperature properties for two 5% chromium alloys. **44**

Alloy Steel. Vanadium-Alloys Steel Co., 26 pp, illus. Tensile, fatigue, low and high temperature properties, uses, weldability, and hardening and surface treatment for a 5% chromium steel called VascoJet 1000. **45**

Alloying Elements. Vanadium Corp. of America, 4 pp. Chemical composition and uses of aluminum, boron, titanium and vanadium as alloying elements in steels. **46**

Investment Casting Alloys. Wai-Met Alloys Co., 4 pp, illus. Information on tool and stainless steel certified alloys for investment castings. **47**

Stainless Steel. Wallingford Steel Co., 52 pp. Chemical composition, comparative properties, corrosion resistance, tolerances and fabrication of stainless steel. **48**

Stainless Steel. Washington Steel Corp., 28 pp, illus. Physical properties, chemical composition, corrosion resistance, and availability of a nickel-free stainless steel called Microrold 430. **49**

Expanded Metal. Wheeling Steel Corp., 8 pp, illus. Dimensional data, weights, applications and styles of expanded metal. **50**

Low Alloy Steel. Youngstown Sheet & Tube Co., 4 pp. Chemical composition, physical properties, machinability and weldability of a high strength, low alloy steel called **Yoloy**. **51**

To get literature, use free post card on p 367, 405 or 479

PROPERTIES OF MATERIALS

Irons and Steels

	PAGE
Gray Irons	32
Nodular or Ductile Irons	34
Malleable Irons	36
Ingot and Wrought Irons	37
Low Carbon Steels	38
Medium Carbon Steels	39
High Carbon Steels	40
Free-Cutting Steels	41
Manganese Steels	42
Nickel Steels	43
Carbon-Molybdenum Steels	44
Nickel-Chromium-Molybdenum Steels (4300)	45
Chromium-Vanadium Steels	46
Nickel-Chromium-Molybdenum Steels (8600, 8700)	47
Manganese-Silicon and Manganese-Nickel-Chromium-Molybdenum Steels	48
Chromium-Manganese Stainless Steels	49
Austenitic Stainless Steels	50
Martensitic Stainless Steels	52
Ferritic Stainless Steels	54
Age Hardening Stainless Steels	55
Cast Carbon Steels	56
Cast Low Alloy Steels	57
Cast Stainless Steels	59
Cast Heat Resistant Alloys	62
Nitriding Steels	65
Advertisements	66
Suppliers' Literature	30

Gray Irons

Class[a] →	20	25	30
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.26	0.26	0.26
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft.	24–34	24–34	24–34
Coef of Ther Exp (32–212 F), per °F	6×10^{-6}	6×10^{-6}	6×10^{-6}
Magnetic?	Yes	Yes	Yes
Electrical Resistivity (68 F), microhm-cm	Varies from 50 to 200 depending on composition		
MECHANICAL PROPERTIES[b]			
Mod of Elast in Tension, psi[c]	$13, 12, 9 \times 10^6$	$14, 13, 11.5 \times 10^6$	$16, 15, 13.5 \times 10^6$
Tensile Strength (as cast), 1000 psi	24–29, 20–24, 15–19	27–33, 25–30, 20–24	35–40, 30–34, 20–24
Transverse Strength (as cast), 1000 lb[d]	1, 2, 5.2	1.25, 2.1, 5.5	1.4, 2.2, 7.3
Deflection (as cast), in.[d]	0.14, 0.25, 0.25	0.17, 0.27, 0.30	0.16, 0.28, 0.31
Modulus of Rupture (as cast), 1000 psi	50, 53, 40	57, 56, 42	63, 58, 56
Hardness (Brinell, as cast)[e]	200, 180, 170	205, 190, 175	210, 200, 180
Fatigue Strength (endurance limit, as cast), 1000 psi[f]	—, 10, —	—, 12.5, —	—, 14.5, —
Compressive Strength (as cast), 1000 psi[g]	100, 95, 90	—, 100, —	—, 115, —
Shear Strength (as cast), 1000 psi	—, 32, —	—, 37, —	—, 44, —
FABRICATING PROPERTIES	Gray cast iron, having a ferrite matrix in which graphite flakes are dispersed, has a machinability rating of 110. When a cast iron microstructure shows alloy segregation, free carbides, steadite and free pearlite, machinability is reduced and may be as low as 40. Some castings show several structures due to cooling rate and section size		
JOINING	Can be joined by gas welding; shielded metal-arc welding using special electrodes; carbon arc welding. Preheating necessary. Can be brazed with nonferrous filler metal		
CORROSION RESISTANCE	More resistant to some types of corrosion than carbon and low alloy steels, possibly because of graphite; cast iron soil pipe usually lasts longer than steel pipe, for example. Gray irons are resistant to strong sulfuric acid, cold concentrated phosphoric and nitric acids; attacked by dilute sulfuric, phosphoric and nitric acids. Resistant to many alkalis, including sodium hydroxide, soda ash and ammonia		
USES	Machine bases, grates, housings, ornamental castings, sanitary wear, piston rings, pipe and fittings	Similar to class 20 where higher strength is required	Light brake drums, clutch plates, cylinder blocks, liners, impellers, pipe and fittings, grate bars, machine parts

[a]Specified min tensile strength, 1000 psi, ASTM A48–48.
[b]Three values are given for light, medium and heavy sections, respectively.
[c]At ¼ max transverse load.
[d]Bar diameters 0.875, 1.2 and 2.0 in., respectively. Distance between supports 12, 18 and 24 in., respectively.
[e]Considerably wider range obtainable by heat treatment.
[f]About 40% of tensile strength appears to be safe level for endurance limit.
[g]In general, compressive strength is three to five times tensile strength.

Gray Irons—concluded

Class[a] →	35	40	50	60
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.26	0.26	0.26	0.26
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	24–34	24–34	24–34	24–34
Coef of Ther Exp (32–212 F), per °F	6 x 10^{-6}	6 x 10^{-6}	6 x 10^{-6}	6 x 10^{-6}
Magnetic?	Yes	Yes	Yes	Yes
Elec Res (68 F), microhm-cm	Varies from 50 to 200 depending on composition			
MECHANICAL PROPERTIES[b]				
Mod of Elast in Tension, psi[c]	17, 16, 14.5 x 10^6	18, 17, 15.5 x 10^6	19, 19, 18 x 10^6	20, 19.5, 19 x 10^6
Ten Str (as cast), 1000 psi	38–42, 35–40, 25–33	50, 40–48, 33–45	60, 50–57, 52	70, 60–66, 50–75
Transverse Str (as cast), 1000 lb[d]	1.5, 2.6, 8	1.75, 2.9, 10	2, 3.3, 10.7	2.5, 3.7, 15
Deflection (as cast), in.[d]	0.17, 0.28 –	0.16, 0.28, 0.30	0.18, 0.28, 0.30	0.13, 0.34, 0.40
Mod of Rupture (as cast), 1000 psi	70, 69, 63	80, 78, 76	91, 88, 82	114, 98, 115
Hardness (Brinell, as cast)[e]	220, 210, 190	230, 220, 210	260, 240, 230	300, 290, 275
Fatigue Str (endur limit, as cast), 1000 psi[f]	–, 17.5, –	–, 21, –	–, 25, –	–, –, –
Compr Str (as cast), 1000 psi[g]	150, 125, –	–, 143, –	–, 150, –	–, 170, –
Shear Str (as cast), 1000 psi	–, 43, –	–, 57, –	–, –, –	–, –, –
FABRICATING PROPERTIES	Gray cast iron, having a ferrite matrix in which graphite flakes are dispersed, has a machinability rating of 110. When a cast iron microstructure shows alloy segregation, free carbides, steadite and free pearlite, machinability is reduced and may be as low as 40. Some castings show several structures due to cooling rate and section size			
JOINING	Can be joined by gas welding, shielded metal-arc welding using special electrodes, carbon arc welding. Preheating necessary. Can be brazed with nonferrous filler metal			
CORROSION RESISTANCE	More resistant to some types of corrosion than carbon and low alloy steels, possibly because of graphite; cast iron soil pipe usually lasts longer than steel pipe, for example. Gray irons are resistant to strong sulfuric acid, cold concentrated phosphoric and nitric acids; attacked by dilute sulfuric, phosphoric and nitric acids. Resistant to many alkalis, including sodium hydroxide, soda ash and ammonia			
USES	Clutch plates, crankcases, light brake-drums, liners, sleeves, cylinder blocks, impellers, machine components	Gears, camshafts, heads, liners, valves, pumps, tube supports, dies, wheels	Gears, valves, heads, blocks, steam pressure castings, dies, compressors, pumps, rams	Special brake drums, pressure castings, crusher frames, hot forming dies, heavy duty gears, hydraulic cylinders

[a]Specified min tensile strength, 1000 psi, ASTM A48–48.
[b]Three values are given for light, medium and heavy sections, respectively.
[c]At ¼ max transverse load.
[d]Bar diameters 0.875, 1.2 and 2.0 in., respectively. Distance between supports 12, 18 and 24 in., respectively.
[e]Considerably wider range obtainable by heat treatment.
[f]About 40% of tensile strength appears to be safe level for endurance limit.
[g]In general, compressive strength is three to five times tensile strength.

Nodular or Ductile Irons

Type ➡	80-60-3	60-45-10	100-75-04[a]
COMPOSITION, %	T.C. 3.3–3.8, Si 2.0–3.0, Mn 0.2–0.5, P 0.06–0.08, Ni 0–1.0, Mg 0.02–0.07	T.C. 3.4–4.0, Si 2.0–2.75, Mn 0.2–0.6, P 0.06–0.08, Ni 0–1.0, Mg 0.02–0.07	T.C. 3.4–3.8, Si 2.0–2.75, Mn 0.3–0.6, P 0.08 max, Ni 0–2.5, Mo 0-1.0, Mg 0.02-0.07
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.257	0.257
Melting Temp Range, F	2050–2150	2050–2150	2050–2150
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	18	20	—
Coef of Ther Exp (70–400 F), per °F	6.6×10^{-6}	6.6×10^{-6}	6.6×10^{-6}
Electrical Resistivity (75 F), microhm-cm	68[b]	66[b]	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$22–25 \times 10^6$	$22–25 \times 10^6$	$22–25 \times 10^6$
Tensile Strength, 1000 psi	90–110	60–80	100–120
Yield Strength, 1000 psi	60–75	45–60	75–90
Elongation (in 2 in.), %	3–10	10–25	6–10
Hardness (Brinell)	200–270	140–190	200–240
Impact Strength (Charpy), ft-lb			
Unnotched	15–65	60–115	35–50
Notched	2–5	10–15	—
Fatigue Strength	Endurance ratio follows pattern of other ferrous materials. For soft ferritic materials, notched endurance ratio is about 50-55%; with stronger irons, the ratio drops to 30-40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi			
800 F	19,000	14,000	—
1000 F	1,750	4,000	—
1200 F	480	550	—
1400 F	—	—	—
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600–1650 F range, cool to 1300 F, hold 1-3 hr, furnace cool to 1100 F, air cool		
Pearlitic-Ferritic Structures	Heat to 1600–1650 F, cool rapidly, reheat at 1100–1300 F		
Pearlitic Structures	Normalize by air cooling from 1600–1650 F		
Tempered Structures	Quench from 1400–1650 F (depending on composition), temper at 800–1300 F		
FABRICATING PROPERTIES			
Machinability	Depends on structure but has excellent machinability in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar composition		
USES	Anvils for forging hammers; impellers, levers, cams, crankshafts, dies, jet engine burner support rings	Valve and pump bodies, pipe fittings, clamps, gear housings; tractor and farm machine parts	Track shoes, brake drums, gears, camshafts, pistons

[a]Obtained by heat treatment involving normalizing or quenching and tempering.
[b]Iron containing 1% silicon.

Nodular or Ductile Irons—concluded

Type →	120-90-02[a]	Heat Resistant	Austenitic
COMPOSITION, %	T.C. 3.4–3.8, Si 2.0–2.75, Mn 0.3–0.6, P 0.08 max, Ni 0–2.5, Mo 0–1.0, Mg 0.02–0.07	T.C. 2.8–3.8, Si 2.5–6.0, Mn 0.2–0.6, P 0.08 max, Ni 0–1.5, Mg 0.02–0.07	T.C. 3.0, Si 2.0–3.2, Mn 0.8–1.5, P 0.02 max, Ni 18–22, Cr 0–2.5
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.257	0.25	0.268
Melting Temp Range, F	2050–2150	2050–2150	2250
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	—	—	—
Coef of Ther Exp (70–400 F), per °F	6.6×10^{-6}	—	10.4×10^{-6}
Electrical Resistivity (75 F), microhm-cm	—	—	102
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	$22–25 \times 10^6$	$22–25 \times 10^6$	18.5×10^6
Tensile Strength, 1000 psi	120–150	60–100	58–68
Yield Strength, 1000 psi	90–125	45–75	32–38
Elongation (in 2 in.), %	2–7	0–20	7–40[c]
Hardness (Brinell)	240–325	140–300	140–200
Impact Strength (Charpy), ft-lb			
Unnotched	25–40	5–115	—
Notched	—	—	10–28
Fatigue Strength	Endurance ratio follows pattern set with other ferrous materials. For soft ferritic materials, notched endurance ratio is 50–55%; with the stronger irons, ratio drops to 30–40% or lower		
Compressive Strength	Ratio of compressive strength to tensile strength is about 2 to 1		
Creep Strength (0.0001%/hr), psi[d]			
800 F	—	—	18,500
1000 F	—	—	13,000
1200 F	—	—	5,700
1400 F	—	—	2,000
THERMAL TREATMENT			
Ferritic Structure (ferritizing anneal)	Heat in 1600–1650 F range, cool to 1300 F, hold 1–3 hr, furnace cool to 1100 F, air cool		—
Pearlitic-Ferritic Structures	Heat to 1600–1650 F, cool rapidly, reheat at 1100–1300 F		—
Pearlitic Structures	Normalize by air cooling from 1600–1650 F		—
Tempered Structures	Quench from 1400–1650 F (depending on composition), temper at 800–1300 F		—
FABRICATING PROPERTIES			
Machinability	Depends on structure but is excellent in both as-cast and annealed conditions		
Weldability	Can be welded by most fusion welding processes. For maximum ductility, welding should be done on fully annealed material. Composition affects weld quality. A 60 Ni-40% Fe filler wire is best for metal arc welding. Can be brazed with the lower melting BAg filler metals		
CORROSION RESISTANCE	Approx same corrosion resistance as gray irons of similar composition; superior to ordinary gray irons		
USES	Machine guides, pinions, gears, cams, dies, track rollers	Grate boxes, sinter pots, lead pots, glass molds, furnace doors	Impellers, grids, paper mill machine parts, pumps, valves

[a]Obtained by heat treatment involving normalizing or quenching and tempering.
[c]25–40% with 0% chromium.
[d]For 0% chromium.

Malleable Irons

Type and Grade →	Standard		Pearlitic
	32510	35018	
COMPOSITION, %	C 2.3–2.7, Si 1.5–0.8, Mn 0.55 max, P 0.18 max, S 0.20 max	C 2.0–2.45, Si 1.4–0.85, Mn 0.55 max, P 0.18 max, S 0.20 max	Same as standard grades except that manganese can be higher
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.259–0.263	0.259–0.263	0.259–0.263
Thermal Conductivity, Btu/hr/sq ft/°F/ft			
80 F	29.5	29.5	[a]
700 F	23.0	23.0	[a]
Coef of Ther Exp (68–750 F), per °F	6.6×10^{-6}	6.6×10^{-6}	[a]
Specific Heat (70-750 F), Btu/lb/°F	0.133	0.133	—
Electrical Resistivity (68 F), microhm-cm	32.0	32.0	38.19–41.17
Magnetic?	Yes	Yes	Yes
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	25×10^6	25×10^6	28×10^6
Tensile Strength, 1000 psi	50–52	53–60	60–90
Yield Strength, 1000 psi	32–35	35–40	40–70
Elongation (in 2 in.), %	10–18	18–25	12–3
Reduction of Area, %	18–23	18–23	—
Hardness (Brinell)	110–145	110–145	160–285
Impact Strength (Charpy), ft-lb[c]	16.5	16.5	12
Fatigue Strength			
Endurance Limit, 1000 psi	25	31	30–32
Endurance Ratio	0.50	0.50	—
Mod of Elast in Compression, psi	25×10^5	25×10^5	—
Compressive Yield Strength, 1000 psi			
1% Permanent Set	28	28	43
At Failure	90+	90+	—
Ultimate Shear Strength, 1000 psi	45–48	48–54	—
Yield Strength in Shear, 1000 psi	29–32	32–36	—
Mod of Rupture in Torsion, psi	58,000	58,000	—
Poisson's Ratio	0.17	0.17	—
Allowable Working Stress (775 F), psi	5600	5600	—
THERMAL TREATMENT			
Hardening Temp, F	1500[b]	1500[b]	1500
Tempering Temp, F	—	—	About 600
FABRICATING PROPERTIES			
Casting Temperature Range, F	2600–2800	2600–2850	2600–2850
Shrinkage Allowance (contraction minus expansion during anneal), in.	11/64–1/32	11/64–1/32	11/64–1/32
Machinability Index (AISI B1112 steel = 100)	120	120	80–90
Weldability	Not fusion welded. Can be soldered and brazed		
CORROSION RESISTANCE	Resistant to atmospheric corrosion in rural, industrial and marine atmospheres; fresh and salt waters		
USES	Gear cases, brake supports, journal boxes, pipe fittings, pole line hardware, ordnance parts, marine deck fittings, anchors, parts for domestic appliances and business machines		Rocker arms, camshafts, gears, sprockets, tractor parts, agricultural machinery parts

[a] Estimated to be somewhat higher than for standard grades.
[b] Must be first heated to 1700 F to dissolve graphitic carbon.
[c] V-notch 0.079 in. deep, 0.894-in. sq bar.

Ingot and Wrought Irons

Type →	Ingot Iron	Wrought Iron	
COMPOSITION, %	C<0.02, Mn<0.02, Si trace, P 0.005, S 0.02	C 0.02, Mn 0.03, Si 0.15, P 0.12, S 0.02, slag 3.0	
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.28	0.25	
Melting Point, F	2794	2750	
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	38	36	
Coef of Ther Exp (68–212 F), per °F	6.8×10^{-6}	6.7×10^{-6}	
Specific Heat, Btu/lb/°F	0.11	0.11	
Electrical Resistivity (68 F), microhm-cm	9.7	—	
Magnetic?	Yes	Yes	
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	29.8×10^6	29×10^6	
		Longitudinal[a]	Transverse[a]
Tensile Strength, 1000 psi			
Annealed	42	—	—
Hot Rolled	44	47	34
Cold Drawn	73	—	—
Yield Point, 1000 psi			
Annealed	19	—	—
Hot Rolled	23	24	23
Cold Drawn	69	—	—
Elongation (in 2 in.), %			
Annealed	48	—	—
Hot Rolled	47	35	7
Cold Drawn	12	—	—
Reduction of Area, %			
Annealed	76	—	—
Hot Rolled	75	48	12
Cold Drawn	63	—	—
Hardness (Brinell)			
Annealed	69	—	—
Hot Rolled	83	105	105
Cold Drawn	142	—	—
Impact Strength (Charpy), ft-lb			
Annealed	19	—	—
Hot Rolled	—	29	11
Cold Drawn	—	—	—
Fatigue Strength (endurance limit), 1000 psi			
Annealed	26	—	—
Hot Rolled	28	23	19
Cold Drawn	33	—	—
FABRICATING PROPERTIES			
Annealing Temperature, F	1700–1800	1300–1400	
Forging Temperature Range, F	—	2100–2200	
Bending Temperature Range, F	—	1300–1400	
Machinability Index (AISI B1112 Steel = 100)	50	50	
Weldability	Readily joined by resistance, arc and gas methods		
CORROSION RESISTANCE	Like other ferrous metals with the exception of the stainless steels, these materials generally require protection for extended service under corrosive conditions. In spite of its purity, ingot iron has corrosion rates much the same as those of plain carbon steel. Under atmospheric conditions, wrought iron appears to be somewhat superior to carbon steel. In fresh water the two materials have similar characteristics; there is some dispute regarding salt water service		
AVAILABLE FORMS	Sheet and strip, wire, rail sections	Tubular products, plate, sheet, bars, structural shapes, wire, chain	
USES	Deep drawn parts, enameling stock, third rails, wire for electrical apparatus	Oil well casing, heat exchangers, piping for fresh and salt water, tanks, bolts and nuts, roofing, chemical processing equipment, chains	

[a]As rolled.

Low Carbon Steels

AISI Type →	C1010	C1015	C1018	C1020	C1025
COMPOSITION, %	C 0.08–0.13, Mn 0.30–0.50, P 0.040 max, S 0.050 max	C 0.13–0.18, Mn 0.30–0.60, P 0.040 max, S 0.050 max	C 0.15–0.20. Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.18–0.23, Mn 0.30–0.60, P 0.040 max, S 0.050 max	C 0.22–0.28, Mn 0.30–0.60, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Melting Temp Range, F	2750–2775	2750–2775	2750–2775	2750–2775	2750–2775
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	14.3	14.3	14.3	14.3	14.3
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi					
Hot Rolled	51	61	69	65	70
Cold Worked	56	74	82	78	80
Yld Str, 1000 psi					
Hot Rolled	29	46	48	43	45
Cold Worked	33	62	70	66	69
Elong (in 2 in.), %					
Hot Rolled	38	39	38	36	31
Cold Worked	35	24	20	20	18
Red. of Area, %					
Hot Rolled	70	61	62	59	58
Cold Worked	65	57	57	55	48
Hardness (Brinell)					
Hot Rolled	101	126	143	143	143
Cold Worked	113	143	163	156	162
Impact Str	Markedly dependent on section size and processing details, such as deoxidation practice, rolling practice, etc.—more so than other mechanical properties				
Fatigue Str	Dependent on thermal and mechanical history, though not to the extent that impact strengths are. Conservative estimate of fatigue strength is 40–50% of tensile strength				
THERMAL TREATMENT					
Annealing Temp, F	1650–1750	1650–1750	1650–1750	1650–1750	1600–1700
Hardening Temp, F	1650–1700[a]	1650–1700[a]	1650–1700[a]	1600–1675[b]	1600–1675[b]
Tempering Temp, F	300–1350	300–1350	300–1350	300–1350	300–1350
FABRICATING PROPERTIES					
Machinability Index[c]					
Hot Rolled	40	50	52	50	52
Cold Worked	45	58	65	60	65
Weldability	Easily welded by all commercial welding procedures, including gas, arc, bronze, thermit, oxyacetylene and submerged-melt processes. Resulting welds are of extremely high quality				
CORROSION RESISTANCE	Rusted by oxygen and water at room temperature, rate of attack increasing sharply as pH goes above 4 and decreasing below a pH of 8. Dilute salt solutions increase corrosion rate. Attacked by acids, in general, but satisfactorily resistant to alkalis at normal temperatures. Corrosion rate in ordinary rusting not appreciably affected by carbon or alloy content or by cold working				
AVAILABLE FORMS	Can be obtained in all mill forms. "Structural mild steel," in which the common shapes are supplied unless otherwise specified, falls somewhere in these ranges of composition				
USES	Can be carburized to give a hard surface on a part which retains its tough inner core. Machine applications apart from structural shapes include automobile spiders, gears, clutch disks, bolts, bearing races, camshafts, crankshafts, piston pins, cams, pneumatic tool cylinders, gun blocks, bushings, stud and collar bolts, shifter shoes, draw bars, pivot pins, cap screws, precision shafting, scythe blade heels, flanges, shackles, tie rods, drag links, steering gear connecting rods, thrust washers, wrenches				

[a]Quench in water, brine or caustic frequently used.
[b]Soluble oil solution used for hardening bolts; mineral oil used when quenching for machinability.
[c]Based on AISI B1112 steel = 100.

Medium Carbon Steels

AISI Type →	C1030	C1035	C1040	C1045
COMPOSITION, %	C 0.28–0.34, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.32–0.38, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.37–0.44, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.43–0.50, Mn 0.60–0.90, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Temp Range, F	2700–2750	2700–2750	2700–2750	2700–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}
Specific Heat, Btu/lb °F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	19	19	19	19
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi				
Hot Rolled	80	85	91	98
Cold Worked	85	92	100	103
Hard. & Temp	98[a]	103[b]	113[b]	120[c]
Yld Str, 1000 psi				
Hot Rolled	50	54	58	59
Cold Worked	72	79	88	90
Hard. & Temp	70[a]	72[a]	86[b]	90[b]
Elong (in 2 in.), %				
Hot Rolled	30	30	27	24
Cold Worked	26	25	17	14
Hard. & Temp	27[a]	23[b]	23[b]	18[b]
Red. of Area, %				
Hot Rolled	56	53	50	45
Cold Worked	51	50	42	40
Hard. & Temp	64[a]	59[b]	62[b]	52[c]
Hardness (Brinell)				
Hot Rolled	163	183	201	212
Cold Worked	179	201	207	217
Hard. & Temp	212[a]	230[b]	235[b]	277[c]
Impact Str	Markedly dependent on section size and processing details such as deoxidation practice, rolling practice, etc.—more so than other mechanical properties			
Fatigue Str	Dependent on thermal and mechanical history, though not to the extent that impact strengths are. A conservative estimate of fatigue strength is 40–50% of tensile strength			
THERMAL TREATMENT				
Annealing Temp, F	1550–1700	1500–1650	1450–1600	1450–1600
Hardening Temp, F[d]	1575–1650	1525–1600	1500–1575	1475–1550
Tempering Temp, F	300–1350	300–1350	300–1350	300–1350
FABRICATING PROPERTIES				
Machinability Index (AISI B1112 steel=100)				
Cold Worked	67	67	65	60
Hard. & Temp	55	55	55	50
Weldability	Easily welded by all commercial procedures including gas, arc, bronze, thermit, oxyacetylene and submerged-melt. Preheat and postheat treatments frequently necessary			
CORROSION RESISTANCE	Rusted by oxygen and water at room temperature, rate of attack increasing sharply as the pH goes above 4 and decreasing below a pH of 8. Dilute salt solutions increase corrosion rate. Attacked by acids, in general, but satisfactorily resistant to alkalis at normal temperatures. Corrosion rate in ordinary rusting not appreciably affected by carbon or alloy content or by cold working			
AVAILABLE FORMS	Can be furnished in all standard mill forms			
USES	Shafts, brake shoe parts, gears, tie rods, brake and clutch pedals, truck rim side rings, sucker rods, connecting rods, shifter levers, pitman arms, flywheel rings, I-beam axles, crankshafts, camshafts, wheel hubs, pins, tools, plowshares, sway bars, mine bits, lock washers, bumper bars, springs, road scraper blades, scarifier teeth, grinding balls			

[a] 1-in. round water quenched 1575, tempered at 1000 F.
[b] 1-in. round water quenched 1525 F, drawn at 1000 F.
[c] 1-in. round water quenched 1550, tempered at 1000 F.
[d] Quenched in oil, water, or brine or caustic solutions.

High Carbon Steels

AISI Type →	C1055	C1060	C1070	C1080	C1095
COMPOSITION, %	C 0.50–0.60, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.55–0.65, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.65–0.75, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.75–0.88, Mn 0.60–0.90, P 0.040 max, S 0.050 max	C 0.90–1.05, Mn 0.30–0.50, P 0.040 max, S 0.050 max
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	18	18	18	18	18
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi					
Annealed (1450 F)	97	105	112	119	100
Hot Rolled	109	116	128	141	142
Hard. & Temp	150[a]	160[a]	174[b]	189[b]	180[c]
Yld Str, 1000 psi					
Annealed	52	54	60	66	53
Hot Rolled	65	70	77	84	84
Hard. & Temp	105	112	127	142	118
Elong (in 2 in.), %					
Annealed	24	20	17	15	21
Hot Rolled	19	17	15	12	9
Hard. & Temp	14	12	13	14	11
Red. of Area, %					
Annealed	47	44	34	22	42
Hot Rolled	38	36	27	17	18
Hard. & Temp	45	40	37	34	30
Hardness (Brinell)					
Annealed	185	192	207	223	197
Hot Rolled	235	241	267	293	293
Hard & Temp	307	321	354	388	375
Impact Str (Izod), ft-lb					
Annealed	22	15	11	6	5
Hot Rolled	18	13	9	5	3
Hard. & Temp	22	15	13	10	5
THERMAL TREATMENT					
Normalizing Temp, F	1525–1650	1525–1650	1525–1650	1525–1650	1525–1650
Annealing Temp, F	1500–1575	1500–1575	1500–1575	1500–1575	1500–1575
Hardening Temp, F	1450–1550	1450–1550	1450–1525	1450–1500	1430–1500
Tempering Temp, F	400–1300	400–1300	400–1300	400–1300	400–1300
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1550–1650	1550–1650	1550–1650	1550–1650	1550–1650
Machinability Index (annealed)[d]	55	53	45	44	43
Weldability	High carbon content introduces difficulties in welding. Can be welded satisfactorily by thermit process. Welding by gas and arc methods is difficult, and resulting welds are only moderately satisfactory				
CORROSION RESISTANCE	Rust when brought into contact with moisture and air at room temperature; rates not appreciably affected by carbon content. If salts are present, corrosion rate is increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures				
AVAILABLE FORMS	Cold rolled strip, hot rolled strip, flat bars, forgings				
USES	Heavy machine parts, such as shafts, braces and control rods; hand tools, including open-end and Stillson wrenches, hammers, pliers, screwdrivers, hatchets and axes; agricultural machinery parts, such as plowshares, mold boards, disks for harrows, and mower knives; and flat and helical springs				

[a] 1-in. round, normalized 1650 F, reheated to 1550 F, oil quenched, tempered 700 F.
[b] 1-in. round, normalized 1650 F, reheated to 1525 F, oil quenched, tempered 700 F.
[c] 1-in. round, normalized 1650 F, reheated to 1475 F, oil quenched, tempered 700 F.
[d] Based on AISI B1112 steel = 100.

Free-Cutting Steels

AISI Type[a] →	B1111, C1211	B1112, C1212	B1113, C1213
COMPOSITION, %	C 0.13 max, Mn 0.60–0.90, P 0.07–0.12, S 0.08–0.15	C 0.13 max, Mn 0.70–1.00, P 0.07–0.12, S 0.16–0.23	C 0.13 max, Mn 0.70–1.00, P 0.07–0.12, S 0.24–0.33
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.283	0.283	0.283
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.4×10^{-6}	8.4×10^{-6}	8.4×10^{-6}
Specific Heat, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11
Electrical Resistivity (68 F), microhm-cm	14.3	14.3	14.3
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6
Tensile Strength, 1000 psi[c]			
9/16-In. Dia	85–110	85–110	85–110
1-In. Dia	80–105	80–105	80–105
2-In. Dia	70–90	70–90	70–90
Yield Strength, 1000 psi[c]			
9/16-In. Dia	75–100	75–100	75–100
1-In. Dia	70–90	70–90	70–90
2-In. Dia	60–85	60–85	60–85
Elongation (in 2 in.), %[c]			
9/16-In. Dia	10–20	10–20	10–20
1-In. Dia	12–22	12–22	12–22
2-In. Dia	10–20	10–20	10–20
Reduction of Area, %[c]			
9/16-In. Dia	30–50	30–50	30–50
1-In. Dia	35–55	35–55	35–55
2-In. Dia	30–50	30–50	30–50
Hardness (Brinell)[c]			
9/16-In. Dia	B90–102[b]	B90–102[b]	B90–102[b]
1-In. Dia	163–229	163–229	163–229
2-In. Dia	149–202	149–202	149–202
Impact Strength	Relatively low impact strength at low temperatures; should not be used for shock loading applications at subzero temperatures		
Fatigue Strength	Notch sensitive as cold drawn. Polished fatigue specimens will show expected values but poor finishing or processing of parts may cause low and erratic results for finished parts under dynamic or alternating stresses of relatively low intensity		
THERMAL TREATMENT			
Case Hardening	Case hardened for high surface hardness and good wear resistance where core properties not important Case hardness Rockwell C60–65		
Case Hardening Temp, F[d]	1450–1700	1450–1700	1450–1700
Tempering Temp, F	300	300	300
FABRICATING PROPERTIES			
Workability	Not recommended for operations involving cold metal movement, such as crimping, forming or bending		
Machinability Index[e]	90	100	125
Machining Speed (avg), sfm	153	170	213
AVAILABLE FORMS	Cold drawn shapes		
USES	Studs, nuts, fasteners, sleeves, collars, spacers, dowels, rods, handles, levers		

[a]B1111, B1112, B1113 are bessemer steels. C1211, C1212, C1213 are basic open hearth steels.
[b]Rockwell hardness.
[c]Cold drawn.
[d]Quench in water or oil.
[e]Based on AISI B1112 Steel = 100.

Manganese Steels

AISI Type →	1320	1321	1330	1335	1340
COMPOSITION, %	C 0.18–0.23, Mn 1.60–1.90, Si 0.20–0.35, P 0.040 max, S 0.040 max	C 0.17–0.22, Mn 1.80–2.10, Si 0.20–0.35, P 0.050 max, S 0.050 max	C 0.28–0.33, Mn 1.60–1.90, Si 0.20–0.35, P 0.040 max, S 0.040 max	C 0.33–0.38, Mn 1.60–1.90, Si 0.20–0.35, P 0.040 max, S 0.040 max	C 0.38–0.43, Mn 1.60–1.90, Si 0.20–0.35, P 0.040 max, S 0.040 max
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (68–1200 F), per °F	7.9×10^{-6}	7.9×10^{-6}	7.9×10^{-6}	7.9×10^{-6}	7.9×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	17	17	17	17	17
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi					
Annealed	84	90	97	104	110
Cold Drawn	102	107	113	119	—
Hard. & Temp	100[b]	—	122[c]	126[d]	137[d]
Yld Point, 1000 psi					
Annealed	72	80	83	90	94
Cold Drawn	80	87	93	100	—
Hard. & Temp	73.5	—	100	105	118
Elong (in 2 in.), %					
Annealed	24	22	21	19.5	18
Cold Drawn	20	18	15	14	—
Hard. & Temp	28	—	19	20.5	19
Red. of Area, %					
Annealed	60	58	57	55	54
Cold Drawn	57	55	50	47	—
Hard. & Temp	65	—	52	59	55
Hardness (Brinell)					
Annealed	179	187	197	212	223
Cold Drawn	207	212	235	248	—
Hard. & Temp	217	—	248	262	285
Impact Str (Izod), ft-lb					
Annealed	—	—	—	—	52
Cold Drawn	80	—	—	—	56
THERMAL TREATMENT					
Annealing Temp, F	1500–1600	1500–1600	1500–1600	1500–1600	1500–1600
Hardening Temp, F	1575–1625	1575–1625	1500–1575	1500–1550	1500–1550
FABRICATING PROPERTIES					
Machinability Index[e] (annealed or cold drawn)	65	63	62	62	59
Weldability	Manganese increases crack sensitivity of welded joints, particularly when this sensitivity is associated with higher carbon contents. Welding practice must be controlled accordingly				
CORROSION RESISTANCE	Rust at rates similar to those of carbon steels when brought into contact with moisture and air. If salts are present, corrosion rates are increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures				
AVAILABLE FORMS	Billets, hot rolled bars, cold finished bars, forgings				
USES	Automotive, farm implement and miscellaneous industrial applications, including axles, drive shafts, propeller shafts, bolts, studs, gears and tie rods				

[a]Mechanical properties determined on 1-in. round bars.
[b]Pseudo-carburized at 1700 F for 8 hr, oil quenched, tempered at 300 F, reheated at 1475 F.
[c]Water quenched from 1525 F, tempered at 1000 F.
[d]Oil quenched from 1525 F, tempered at 1000 F.
[e]Based on AISI B1112 steel = 100.

Nickel Steels

AISI Type →	2317	2330	2512	2515	2517
COMPOSITION, %	C 0.15–0.20, Mn 0.40–0.60, Si 0.20–0.35, Ni 3.25–3.75	C 0.28–0.33, Mn 0.60–0.80, Si 0.20–0.35, Ni 3.25–3.75	C 0.09–0.14, Mn 0.40–0.60, Si 0.20–0.35, Ni 4.75–5.25	C 0.12–0.17, Mn 0.40–0.60, Si 0.20–0.35, Ni 4.75–5.25	C 0.15–0.20, Mn 0.40–0.60, Si 0.20–0.35, Ni 4.75–5.25
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Melting Point, F	2620	2600	2620	2615	2610
Ther Cond (120 F), Btu/hr/sq ft/°F/ft	38.3	38.3	34.5–38.5	34.5–38.5	34.5–38.5
Coef of Ther Exp, per °F					
0 to 200 F	6.2×10^{-6}	6.2×10^{-6}	6.0×10^{-6}	6.0×10^{-6}	6.0×10^{-6}
0 to 1200 F	8.0×10^{-6}	8.0×10^{-6}	7.8×10^{-6}	7.8×10^{-6}	7.8×10^{-6}
Spec Ht (68–212 F), Btu/lb/°F	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12
Elec Res (annealed), microhm-cm					
120 F	28.4	28.4	27–29	27–29	27–29
570 F	46.8	46.8	—	—	—
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi					
Hot Rolled	81	97	86	90	92
Annealed	77	90	77	80	82
Cold Drawn	95	110	—	103	—
Hard. & Temp (1000 F)[b]	107	125	105	113	120
Yld Str, 1000 psi					
Hot Rolled	55	67	62	67	70
Annealed	53	64	61	63	65
Cold Drawn	75	90	—	75	—
Hard. & Temp (1000 F)[b]	72	96	85	94	100
Elong (in 2 in.), %					
Hot Rolled	29	24	28	26	26
Annealed	31	27	30	25	29
Cold Drawn	25	17	—	24	—
Hard. & Temp (1000 F)[b]	27	22	28	25	22
Red. of Area, %					
Hot Rolled	62	51	70	67	65
Annealed	61	54	72	71	70
Cold Drawn	58	47	—	62	—
Hard. & Temp (1000 F)[b]	71	60	73	69	66
Hardness (Brinell)					
Hot Rolled	160	195	170	180	184
Annealed	152	180	157	160	162
Cold Drawn	197	235	—	207	—
Hard. & Temp (1000 F)[b]	222	270	217	233	244
Impact Str (Izod, hard. & temp at 1000 F)[b], ft-lb	84	55	95	85	80
THERMAL TREATMENT					
Annealing Temp, F	1550	1500	1525	1500	1500
Normalizing Temp, F	1550	1500	1525	1500	1500
Hardening Temp, F	1475	1450	1475	1475	1475
FABRICATING PROPERTIES					
Max Forging Temp, F	2300	2250	2300	2300	2300
Machinability Index[c]	55	50	—	40	—
Weldability	Good	Good	Good	Good	Good
CORROSION RESISTANCE	Better corrosion resistance than plain carbon steels				
AVAILABLE FORMS	Usually supplied as bar stock or forgings, but can be obtained in all steel mill forms		Usually supplied as bar stock, tubing or forgings, but can be obtained in all steel mill forms		
USES	Carburized parts; gears, cams	Shafting, heavy forgings, gears	Heavy duty carburized parts such as aircraft gears and piston pins. Uncarburized, used for corrosion resistant process equipment		

[a] For design purposes, fatigue strength is approximately 50% of tensile strength. Compressive yield strength is about equal to tensile yield strength. Shear strength is about 5 to 10% less than tensile strength.

[b] Properties after heat treatment are based on oil quench and 1-in. round bars.

[c] Based on AISI B1112 steel = 100.

Carbon-Molybdenum Steels

AISI Type ➡	4023	4032	4042	4053	4063
COMPOSITION, %	C 0.20–0.25, Mn 0.70–0.90, P 0.040 max, S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30	C 0.30–0.35, Mn 0.70–0.90, P 0.040 max, S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30	C 0.40–0.45, Mn 0.70–0.90, P 0.040 max, S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30	C 0.50–0.56, Mn 0.75–1.00, P 0.040 max, S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30	C 0.60–0.67, Mn 0.75–1.00, P 0.040 max S 0.040 max, Si 0.20–0.35, Mo 0.20–0.30
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3 x 10^{-6}	8.3 x 10^{-6}	8.3 x 10^{-6}	8.3 x 10^{-6}	8.3 x 10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	19	19	19	19	19
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6
Ten Str, 1000 psi					
Annealed, Cold Drawn	88	92	96	102	109
Cold Drawn	90	104	117	127	137
Hard. & Temp	120[a], 108[b]	210[c], 140[d]	235[e], 158[f]	250[g], 165[h]	269[i], 173[j]
Yld Point, 1000 psi					
Annealed, Cold Drawn	76	79	82	88	94
Cold Drawn	75	89	101	108	115
Hard. & Temp	85[a], 64[b]	182[c], 128[d]	210[e], 140[f]	223[g], 150[h]	231[i], 150[j]
Elong (in 2 in.), %					
Annealed, Cold Drawn	22	20	19	18	16
Cold Drawn	21	17	16	14	13
Hard. & Temp	20[a], 21[b]	11[c], 18[d]	10[e], 15[f]	12[g], 16[h]	8[i], 13[j]
Red. of Area, %					
Annealed, Cold Drawn	57	54	53	51	48
Cold Drawn	55	51	49	45	40
Hard. & Temp	53[a], 54[b]	49[c], 63[d]	42[e], 60[f]	40[g], 56[h]	15[i], 40[j]
Hardness (Brinell)					
Annealed, Cold Drawn	179	192	202	212	223
Cold Drawn	183	217	241	262	277
Hard. & Temp	255[a], 229[b]	415[c], 302[d]	461[e], 302[f]	495[g], 352[h]	534[i], 380[j]
Fatigue Str, 1000 psi	Endurance limit is proportional to tensile strength in same ratio as in other low alloy steels. Below 400 Bhn, ratio is about 50%; at higher hardness, endurance limit is about 45% of tensile strength				
THERMAL TREATMENT					
Annealing Temp, F	1650	1550–1600	1525–1575	1450–1550	1450–1550
Hardening Temp (oil quench), F	[k]	[l]	1500–1575	1475–1550	1475–1550
FABRICATING PROPERTIES					
Machinability Index (AISI B1112 = 100)	73	70	65	56	52
Weldability	Can be welded by procedures used for carbon steels. Molybdenum increases hardenability; preheating or postheating may be required				
CORROSION RESISTANCE	Similar to carbon steels				
USES	Automotive parts such as countershafts, transmission shafts, spline and differential gears	Automotive transmission gears and pinions, bolts	Leaf and coil springs, bolts, axles, steering arms and knuckles. Hand tools such as screw drivers	Leaf and coil springs. Hand tools such as chisels	

[a] 1-in. round pseudo-carburized 8 hr at 1700 F, oil quenched, tempered 1 hr at 300 F.
[b] Same as [a] but reheated at 1475 F, oil quenched.
[c] Water quenched from 1525 F, tempered at 600 F.
[d] Water quenched from 1525 F, tempered at 1000 F.
[e] Oil quenched from 1500 F, tempered at 600 F.
[f] Oil quenched from 1500 F, tempered at 1000 F.
[g] Oil quenched from 1475 F, tempered at 600 F.
[h] Oil quenched from 1475 F, tempered at 1000 F.
[i] Oil quenched from 1450 F, tempered at 600 F.
[j] Oil quenched from 1450 F, tempered at 1000 F.
[k] Carburize 1650-1700 F; quench fine grained steels directly from carburizing temperature.
[l] Carburize 1650-1700 F; quench fine grained steels directly from carburizing temperature. Water quench from 1500-1550 F if not carburized.

Nickel-Chromium-Molybdenum Steels (4300)

AISI Type ➡	4317	4320	4337	4340
COMPOSITION, %	C 0.15–0.20, Mn 0.45–0.65, Ni 1.65–2.00, Cr 0.40–0.60, Mo 0.20–0.30	C 0.17–0.22, Mn 0.45–0.65, Ni 1.62–2.00, Cr 0.40–0.60, Mo 0.20–0.30	C 0.35–0.40, Mn 0.60–0.80, Ni 1.65–2.00, Cr 0.70–0.90, Mo 0.20–0.30	C 0.38–0.43, Mn 0.60–0.80, Ni 1.65–2.00, Cr 0.70–0.90, Mo 0.20–0.30
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Point, F	2750	2750	2740	2740
Ther Cond (120 F), Btu/hr/sq ft/°F/ft	21.7	21.7	21.7	21.7
Coef of Ther Exp, per °F				
0 to 200 F	6.3×10^{-6}	6.3×10^{-6}	6.3×10^{-6}	6.3×10^{-6}
0 to 1200 F	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/lb/°F	0.107	0.107	0.107	0.107
Elec Res, microhm-cm				
120 F	30	30	30	30
570 F	48	48	48	48
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi				
As Rolled	122	134	180	192
Annealed	95	98	115	119
Hard & Temp[a]	160[b]	180[b]	140[e], 210[d]	150[e], 220[d]
Yld Str, 1000 psi				
As Rolled	99	102	141	147
Annealed	77	89	96	99
Hard & Temp[a]	130[b]	154[b]	120[e], 190[d]	130[e], 200[d]
Elong (in 2 in.), %				
As Rolled	19	17	11	9
Annealed	25	23	19	17
Hard. & Temp[a]	17[b]	15[b]	21[e], 14[d]	19[e], 12[d]
Red of Area, %				
As Rolled	47	43	21	19
Annealed	54	52	45	43
Hard. & Temp[a]	57[b]	50[b]	59[e], 50[d]	57[e], 48[d]
Hardness (Brinell)				
As Rolled	250	265	365	380
Annealed	185	195	230	240
Hard. & Temp[a]	320[b]	360[b]	300[e], 435[d]	310[e], 445[d]
Impact Str (Izod, hard. & temp[a]), ft-lb	40[b]	32[b]	75[e], 18[d]	73[e], 16[d]
FABRICATING PROPERTIES				
Annealing Temp, F	1550–1600	1550–1600	1550–1600	1550–1600
Hardening Temp, F	1525–1575	1525–1575	1475–1550	1475–1550
Max Hot Working Temp, F	2300	2300	2300	2300
Machinability Index[e]	55	51	51	51
Weldability	All grades readily weldable by oxyacetylene, inert arc and electrical resistance methods. Preheating desirable for AISI 4337 and 4340			
CORROSION RESISTANCE	Better corrosion resistance than plain carbon steels			
AVAILABLE FORMS	Usually supplied as bars, forgings, tubing and billets, but can be obtained in all steel mill forms			
USES	Heavy duty carburized parts such as gears, bearing races		Heavy duty, high strength applications, particularly in sections over about 1½ in. thick. Gears, aircraft tubing, shafts, heavy forgings, churn drills	

[a]Properties after heat treatment are based upon oil quench and 1-in. round bars.
[b]These are core properties of pseudo-carburized 1-in. bars, tempered at 300 F.
[c]Tempered at 1200 F. [d]Tempered at 800 F. [e]Based on AISI B1112 steel = 100.

Chromium-Vanadium Steels

AISI Type →	6120	6145	6150	6152
COMPOSITION, %	C 0.17–0.22, Mn 0.70–0.90, Si 0.20–0.35, Cr 0.70–0.90, V 0.10 min	C 0.43–0.48, Mn 0.70–0.90, Si 0.20–0.35, Cr 0.80–1.10, V 0.15 min	C 0.48–0.53, Mn 0.70–0.90, Si 0.20–0.35, Cr 0.80–1.10, V 0.15 min	C 0.48–0.53, Mn 0.70–0.90, Si 0.20–0.35, Cr 0.80–1.10, V 0.10 min
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	21	21	21	21
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi				
Normalized	85	115	158	—
Hard. & Temp	105[a], 125[b]	176[c], 136[d]	187[c], 144[d]	151[e]
Yld Str, 1000 psi				
Normalized	50	75	88	—
Hard. & Temp	71[a], 94[b]	169[c], 130[d]	179[c], 138[d]	125[e]
Elong (in 2 in.), %				
Normalized	35	24	23	—
Hard. & Temp	19[a], 21[b]	16[c], 22[d]	13[c], 18[d]	16[e]
Red. of Area, %				
Normalized	67	64	62	—
Hard. & Temp	37[a], 56[b]	52[c], 58[d]	42[c], 53[d]	54[e]
Hardness (Brinell)				
Normalized	185	216	240	—
Hard. & Temp	—	429[c], 311[d]	444[c], 363[d]	—
Impact Str (Izod), ft-lb				
Normalized	102	31	—	—
Hard. & Temp	25[a], 28[b]	20[c], 87[d]	13[c], 63[d]	—
Fatigue Str	Endurance limit is proportional to tensile strength in the same ratio as in other low alloy steels. Below 400 Bhn the ratio is about 50%, and at higher hardnesses it is 45–48% of the tensile strength			
THERMAL TREATMENT				
Normalizing Temp, F	1650–1700	1600–1650	1600–1650	1600–1650
Hardening Temp, F	1600–1650	1550–1650	1550–1650	1550–1650
Tempering Temp, F	375–1200	450–1200	450–1200	450–1200
FABRICATING PROPERTIES				
Formability	Similar to other alloy steels of low chromium content. Hot working temperatures are limited not by brittle ranges but by degree of malleability required for the specific application. Because of stiffening, cold working is somewhat more difficult than with carbon steels			
Machinability Index[f]				
Hot Rolled	27	22	24	24
Normalized	46	27	26	26
Weldability	Weldable by all commercial welding procedures, the difficulty of welding increasing with carbon content. Preheating and postheating treatments sometimes necessary			
CORROSION RESISTANCE	Similar to carbon steels. Chromium content too low to have appreciable influence on rate of corrosion			
AVAILABLE FORMS	Available in all standard mill forms			
USES	Carburized gears, shafts. piston pins and bushings. Nitrided and carbonitrided parts	Crankshafts, connecting rods, bevel and spur gears, shafts, springs, axles, pins		

[a]Typical core properties; carburized 16 hr at 1680 F, pot cooled, oil quenched from 1425 F, tempered at 300 F.
[b]Same as [a] but oil quenched from 1525 F.
[c]Normalized at 1600 F, oil quenched from 1575 F, tempered at 1000 F.
[d]Same as [c] but tempered at 1200 F.
[e]Oil quenched from 1575 F, tempered at 1000 F.
[f]Based on AISI B1112 steel = 100.

Nickel-Chromium-Molybdenum Steels (8600, 8700)

AISI Type ➡	8620, 8720	8630	8640, 8740	8650, 8750
COMPOSITION, %	C 0.18–0.23, Mn 0.70–0.90, Ni 0.40–0.70, Cr 0.40–0.60, Mo 0.15–0.25 (8620), 0.20–0.30 (8720)	C 0.28–0.33, Mn 0.70–0.90, Ni 0.40–0.70, Cr 0.40–0.60, Mo 0.15–0.25	C 0.38–0.43, Mn 0.75–1.00, Ni 0.40–0.70, Cr 0.40–0.60, Mo 0.15–0.25 (8640), 0.20–0.30 (8740)	C 0.48–0.53, Mn 0.75–1.00, Ni 0.40–0.70, Cr 0.40–0.60, Mo 0.15–0.25 (8650), 0.20–0.30 (8750)
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Melting Point, F	2755	2750	2745	2745
Ther Cond (120 F), Btu/hr/sq ft/°F/ft	21.7	21.7	21.7	21.7
Coef of Ther Exp, per °F				
0 to 200 F	6.45×10^{-6}	6.45×10^{-6}	6.45×10^{-6}	6.45×10^{-6}
0 to 1200 F	8.25×10^{-6}	8.25×10^{-6}	8.25×10^{-6}	8.25×10^{-6}
Spec Ht, Btu/lb/°F	0.107	0.107	0.107	0.107
Elec Res, microhm-cm				
120 F	30	30	30	30
570 F	48	48	48	48
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str, 1000 psi				
Normalized	94	112	130	149
As Rolled	91	109	126	143
Annealed	77	86	95	105
Hard. & Temp (800 F)[a]	122, 96[b]	162, 111[b]	208, 130[b]	214, 136[b]
Yld Str, 1000 psi				
Normalized	61	73	85	96
As Rolled	65	78	90	101
Annealed	51	58	63	70
Hard. & Temp (800 F)[a]	98, 76[b]	142, 92[b]	183, 110[b]	194, 116[b]
Elong (in 2 in.), %				
Normalized	29	23	18	11
As Rolled	29	25	20	17
Annealed	32	29	27	23
Hard. & Temp (800 F)[a]	21, 26[b]	14, 23[b]	13, 21[b]	12, 21[b]
Red. of Area, %				
Normalized	61	52	45	36
As Rolled	56	48	40	31
Annealed	64	59	55	50
Hard. & Temp (800 F)[a]	63, 70[b]	54, 66[b]	43, 60[b]	41, 61[b]
Hardness (Brinell)				
Normalized	190	225	262	300
As Rolled	185	220	244	290
Annealed	163	174	193	210
Hard. & Temp (800 F)[a]	245, 193[b]	325, 225[b]	420, 262[b]	423, 271[b]
Impact Str (Izod, hard. & temp at 800 F), ft-lb[a]	76, 105[b]	42, 91[b]	18, 68[b]	—
FABRICATING PROPERTIES				
Annealing Temp, F	1550–1600	1550–1600	1550–1600	1550–1600
Hardening Temp, F	1525–1575	1525–1575	1500–1550	1475–1550
Max Hot Working Temp, F	2200	2200	2200	2150
Machinability Index[c]	57[d]	61[e]	55[e]	45[e]
Weldability	Readily weldable by oxyacetylene, inert arc and electrical resistance methods. Preheating desirable for grades with more than 0.30% carbon content			
CORROSION RESISTANCE	Better corrosion resistance than plain carbon steels			
AVAILABLE FORMS	Usually supplied as bars, forgings, tubing or billets; sometimes in other steel mill forms			
USES	Medium duty carburized parts such as gears, cams, bearing races		Medium duty, high strength applications, particularly in sections not over approx 2 in. thick. Gears, bolts, aircraft tubing, hand tools, shafts, forgings	

[a]Properties after heat treatment are based upon an oil quench and 1-in. round bars. [b]Tempered at 1200 F.
[c]Based on AISI B1112 steel = 100. [d]As rolled. [e]Annealed.

Manganese-Silicon and Manganese-Nickel-Chromium-Molybdenum Steels

AISI Type →	9255	9261	9440	9450
COMPOSITION, %	C 0.50–0.60, Mn 0.70–0.95, Si 1.80–2.20	C 0.55–0.65, Mn 0.75–1.00, Si 1.80–2 20, Cr 0.10–0.25	C 0.38–0.43, Mn 0.90–1.20, Si 0.20–0.35, Ni 0.30–0.60, Cr 0.30–0.50, Mo 0.08–0.15	C 0.43–0.48, Mn 1.00–1.30, Si 0.20–0.35, Ni 0.30–0.60, Cr 0.30–0.50, Mo 0.08–0.15
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}	8.1×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.11–0.12	0.11–0.12
Elec Res (68 F), microhm-cm	19	20	20	20
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6	29×10^6
Ten Str, 1000 psi				
Normalized	132[a]	150[c]	115[e]	158[e]
Hard. & Temp (800 F)	232[b]	258[d]	192[f]	210[g]
Hard. & Temp (1200 F)	144[b]	148[d]	120[f]	132[g]
Yld Str, 1000 psi				
Normalized	90	80	74	110
Hard. & Temp (800 F)	215	226	179	192
Hard. & Temp (1200 F)	118	125	102	120
Elong. (in 2 in.), %				
Normalized	18	15	24	15
Hard. & Temp (800 F)	9	10	15	12
Hard. & Temp (1200 F)	20	18	23	20
Red. of Area, %				
Normalized	38	30	50	30
Hard. & Temp (800 F)	21	30	56	48
Hard. & Temp (1200 F)	42	40	67	57
Hardness (Brinell)				
Normalized	277	311	235	331
Hard. & Temp (800 F)	477	514	388	429
Hard. & Temp (1200 F)	285	311	248	285
Impact Str (Izod), ft-lb				
Normalized	12	5	48	8
Hard. & Temp (800 F)	6	12	35	14
Hard. & Temp (1200 F)	22	35	99	72
THERMAL TREATMENT				
Normalizing Temp, F	1625–1675	1600–1650	1575–1625	1575–1625
Hardening Temp, F	1500–1650	1500–1650	1500–1550	1500–1550
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1750–2175	1750–2175	1750–2175	1750–2175
Machinability Index (AISI B1112 steel = 100)	38	36	42	40
Weldability	Welding not normally recommended because high carbon and silicon contents introduce difficulty		High carbon content introduces difficulty in welding. With special techniques and electrodes, satisfactory arc welds can be made	
CORROSION RESISTANCE	Better than plain carbon steels in industrial atmosphere and about the same when continuously exposed to moisture. If salts are present, corrosion is increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures			
AVAILABLE FORMS	Billets, bars, forgings			
USES	Coil and flat springs, lock washers, axes, chisels, hand tools, diesel engine connecting rod bolts, collets for machine tools		Not in general use today. Formerly used for automotive, diesel engine and aircraft parts; bolts; chain; gears	

[a]Normalized at 1650 F. [b]Normalized at 1650 F, reheated to 1625 F, quenched in agitated oil.
[c]Normalized at 1600 F. [d]Normalized at 1600 F, reheated to 1575 F, quenched in agitated oil.
[e]Normalized at 1600 F. [f]Normalized at 1600 F, reheated to 1525 F, quenched in agitated oil.
[g]Normalized at 1600 F, reheated to 1500 F, quenched in agitated oil.

Chromium-Manganese Stainless Steels

AISI Type ➡	201	202
COMPOSITION, %	C 0.15 max, Mn 5.5–7.5, Cr 16.0–18.0, Ni 3.5–5.5, N 0.25 max	C 0.15 max, Mn 7.5–10.0, Cr 17.0–19.0, Ni 4.0–6.0, N 0.25 max
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.28	0.28
Ther Cond (68–212 F), Btu/hr/sq ft/°F/ft	9.4	9.4
Coef of Ther Exp, per °F		
32 to 200 F	8.78×10^{-6}	—
32 to 600 F	9.7×10^{-6}	10.2×10^{-6}
32 to 900 F	10.1×10^{-6}	10.6×10^{-6}
32 to 1400 F	—	11.3×10^{-6}
Specific Heat, Btu/lb/°F	0.12	0.12
Electrical Resistivity (68 F), microhm-cm	69	69
Magnetic?	No	No
Magnetic Permeability (max)	1.02	1.02
MECHANICAL PROPERTIES		
Mod of Elast in Tension, psi	28.6×10^6	28×10^6
Tensile Strength, 1000 psi		
Annealed[a]		
Tested at Rm Temp	115, 114, 95[b]	105, —
Tested at 1200 F	—, 50	—
Tested at 1400 F	—, 37	—
Cold Worked[c]		
Quarter Hard	125	—
Half Hard	150	—
Yield Strength, 1000 psi		
Annealed[a]		
Tested at Rm Temp	55, 53, 47[b]	55, —
Tested at 1200 F	—, 21	—
Tested at 1400 F	—, 19	—
Cold Worked[c]		
Quarter Hard	75	—
Half Hard	110	—
Elongation (in 2 in.), %		
Annealed[a]		
Tested at Rm Temp	55, 57, 60[b]	55, —
Tested at 1200 F	—, 36	—
Tested at 1400 F	—, 38	—
Cold Worked[c]		
Quarter Hard	25	—
Half Hard	15	—
Hardness (Rockwell, annealed)	B90	B90
Rupture Stress (annealed, 1000 hr), 1000 psi		
Tested at 1200 F	22.0	—
Tested at 1400 F	7.0	—
THERMAL TREATMENT		
Annealing Temp, F	1850–2050	1850–2050
FABRICATING PROPERTIES		
Hot Working Temp Range, F	2100–2250	2100–2250
Formability	Moderate; similar to type 301	Good; similar to type 302
Machinability	Good	Good
Weldability	Similar to type 301; normally spot welded	Similar to type 302
CORROSION RESISTANCE	Good; similar to type 301	Good; similar to types 302, 304
AVAILABLE FORMS	Sheet, strip, some bar	Rod, bar, sheet, strip, plate
USES	Alternate for type 301, but tests should be made if severe corrosion conditions exist	Alternate for type 302, but tests should be made if severe corrosion conditions exist

[a] Where two values are given, they represent sheet and bar respectively. [b] Welded and annealed.
[c] Minimum value for sheet tested at room temperature.

Austenitic Stainless Steels

AISI Type ➡	301	302	303	304 , 304 ELC
COMPOSITION, %	C 0.08–0.20, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 16–18, Ni 6–8	C 0.08–0.20, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 17–19, Ni 8–10	C 0.15 max, Mn 2 max, P, S or Se 0.07 min, Si 1 max, Cr 17–19, Ni 8–10, Mo or Zr 0.60 max	C 0.08 max (304) or 0.03 max (304 ELC), Mn 2 max, Si 1 max, P 0.04 max, S 0.030 max, Cr 18–20, Ni 8–11
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.29	0.29	0.29	0.29
Melting Point Range, F	2550–2590	2550–2590	2550–2590	2550–2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	9.4	9.4	9.4
Coef of Ther Exp (32–212 F), per °F	9.5 x 10^{-6} [a]	9.9 x 10^{-6}	9.9 x 10^{-6}	9.9 x 10^{-6}
Spec Ht (32–212 F), Btu/lb/°F	0.12	0.12	0.12	0.12
Elec Res (68 F), microhm-cm	72	72	72	72
MECHANICAL PROPERTIES [b]				
Mod of Elast in Tension, psi	28.0 x 10^6	28.0 x 10^6	28.0 x 10^6	28.0 x 10^6
Ten Str, 1000 psi				
Annealed	110, 105, —	90, 90, 85	—, —, 90	85, 85, 85
Cold Worked [d]	185, —, —	—, —, 110 [c]	—, —, 110 [c]	—, —, 110 [c]
Yld Str, 1000 psi				
Annealed	40, 40, —	40, 35, 35	—, —, 35	35, 30, 35
Cold Worked [d]	140, —, —	—, —, 75 [c]	—, —, 75 [c]	—, —, 75 [c]
Elong (in 2 in.), %				
Annealed	60, 55, —	50, 60, 60	—, —, 50	50, 60, 60
Cold Worked [d]	8–9, —, —	—, —, 35 [c]	—, —, 30 [c]	—, —, 60
Red. of Area, %				
Annealed	—, 70, —	—, 70, 70	—. —, 55	—, 70, 70
Cold Worked	—	—, —, 60 [c]	—, —, 50 [c]	—
Hardness [e]				
Annealed	R_B85, —, —	R_B85, R_B80, 150	—, —, 160	R_B80, 150, 150
Cold Worked	R_B41, —, —	—, —, 240 [c]	—, —, 240 [c]	—, —, 240 [c]
Impact Str (Izod), ft-lb				
Annealed	—, 165, —	—, 110, 110	—, —, 80	—, 110, 110
Cold Worked	—	—	—	—, —, 90 [e]
Endurance Limit, 1000 psi				
Annealed	35, 39, —	—, —, 34	—, —, 35	35, 35, 34
Cold Worked	80, —, —	—	—	—
Creep Str (1% ext in 1000 hr), psi				
1000 F	—	17,000	—	17,000
1300 F	—	4,000	—	4,000
1500 F	—	1,200	—	1,200
FABRICATING PROPERTIES				
Annealing Temp, F [f]	1850–2050	1900–2050	1850–2050	1900–2050
Forging Temp (start), F [g]	2200	2100	2100	2200
Machinability	—	Fair; tough	Good; about 65% of screw stock	Fair; tough
Weldability	Very good	Not recommended; may crack		Very good
CORROSION RESISTANCE	Very good atmosphere resistance; slightly less than type 302	Excellent atmosphere resistance; also resists food products, acids and other chemicals	Very good atmosphere resistance; some resistance sacrificed for better machinability	Excellent atmosphere resistance; slightly better than type 302
AVAILABLE FORMS	Sheet, strip, wire	Sheet, strip, plate, bar, wire	Bar, wire	Sheet, strip, plate, bar, wire
USES	Lightweight, high strength applications; transportation equipment, roof drainage and trim	General purpose	General purpose, but where better machinability (than type 302) is required	Light welded construction where corrosive conditions are not too severe

[a] For 32-600 F range. [b] Where three values are given, they represent sheet, plate and bar in that order.
[c] Cold drawn, high tensile 1½-in. dia bar. [d] Minimum value at full hard temper.
[e] Values are Brinell except where Rockwell scale is noted. [f] Cool rapidly after anneal.
[g] Finish forging all grades at 1700 F or above.

Austenitic Stainless Steels—concluded

AISI Type ➡	309	316, 316 ELC	321
COMPOSITION, %	C 0.20 max, Mn 2 max, P 0.04 max, S 0.03 max, Si 1 max, Cr 22–24, Ni 12–15	C 0.10 max (316), C 0.03 max (316 ELC), Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 16–18, Ni 10–14, Mo 2–3	C 0.08 max, Mn 2 max, Si 1 max, P 0.04 max, S 0.03 max, Cr 17–19, Ni 8–11, Ti 5 x C
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.29	0.29	0.29
Melting Point Range, F	2550–2650	2500–2550	2550–2600
Thermal Conductivity (212 F), Btu/hr/sq ft/°F/ft	8	9.4	9.3
Coef of Ther Exp (32–600 F), per °F	9.3×10^{-6}	9.0×10^{-6}	9.5×10^{-6}
Specific Heat (32–212 F), Btu/lb/°F	0.12	0.12	0.12
Electrical Resistivity (68 F), microhm-cm	78	74	72
MECHANICAL PROPERTIES[b]			
Mod of Elast in Tension, psi	29.0×10^6	28.0×10^6	28.0×10^6
Tensile Strength (annealed), 1000 psi	90, 95, 95	90, 85, 80	90, 85, 85
Yield Strength (annealed), 1000 psi	45, 40, 40	40, 35, 30	35, 30, 35
Elongation (in 2 in., annealed), %	45, 45, 45	50, 55, 60	50, 55, 55
Reduction of Area (annealed), %	—, —, 65	—, —, 70	—, —, 65
Hardness (annealed)[c]	R_B85, 170, 160	R_B85, 150, 150	R_B80, 160, 150
Impact Strength (Izod, annealed), ft-lb	—, —, 110	—, —, 110	—, —, 110
Endurance Limit (annealed), 1000 psi	—	39, 39, 38	—, —, 38
Creep Strength (1% ext in 10,000 hr), psi			
1000 F	15,900	25,000	18,000
1300 F	4,500	7,900	4,500
1500 F	1,000	2,800	850
FABRICATING PROPERTIES			
Annealing Temp, F	1900–2050	1850–2050	1900–2050
Forging Temp (start), F[g]	2150	2200	2250
Machinability	Fair; tough	Fair; tough	Fair; tough
Weldability	Good	Very good	Very good
CORROSION RESISTANCE	Excellent atmosphere resistance; better than type 302. Resists destructive heat scaling up to 2000 F	Best of any standard stainless steel. Greater resistance than type 302 to reducing acids, sea water and other corrosive media causing pitting type of corrosion. Intergranular corrosion due to welding eliminated in 316 ELC	Excellent atmosphere resistance; similar to type 302. Not subject to harmful carbide precipitation
AVAILABLE FORMS	Sheet, strip, plate, bar, wire	Sheet, strip, plate, bar, wire	Sheet, strip, plate, bar, wire
USES	Heat resisting applications	Processing equipment exposed to severe corrosive media. Stressed parts that operate at high temperatures	Welded equipment used in the unannealed condition and exposed to corrosive conditions. Equipment that must operate in the sensitization range (800–1650 F)

[b]Where three values are given, they represent sheet, plate and bar in that order.
[c]Values are Brinell except where Rockwell scale is noted.
[g]Finish forging all grades at 1700 F or above.

Martensitic Stainless Steels

AISI Type →	403, 410	414	416	420	431
COMPOSITION, %	C 0.15 max, Cr 11.5–13.5	C 0.15 max, Cr 11.5–13.0, Ni 1.25–2.5	C 0.15 max, Cr 12–14, P, S or Se 0.07 min, Mo or Zr 0.06 max	C > 0.15, Cr 12–14	C 0.20 max, Cr 15–17, Ni 1.25–2.50
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2700–2790	—	2700–2790	2650–2750	2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	14.4	14.4	14.4	14.4	11.7
Coef of Ther Exp, per °F					
32–212 F	5.5×10^{-6}	5.8×10^{-6}	5.5×10^{-6}	5.7×10^{-6}	6.5×10^{-6}
32-1200 F	6.5×10^{-6}	—	6.5×10^{-6}	6.8×10^{-6}	—
Spec Ht (32–212 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (rm temp), microhm-cm	57	70	57	55	72
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Ten Str, 1000 psi					
Annealed	65–75	115–120	75	95	125
Hard. & Temp	90–190	120–200	90–190	230	125–205
Yld Str, 1000 psi					
Annealed	35–50	90–105	40	50	95
Hard. & Temp	60–145	105–150	60–145	195	90–155
Elong (in 2 in.), %					
Annealed	25–35	15–20	30	25	20
Hard. & Temp	15–30	15–20	12–25	8	15–20
Hardness (Brinell)					
Annealed	155	235	155	195	260
Hard. & Temp	180–390	250–410	180–390	500	260–415
Impact Str (Izod), ft-lb					
Annealed	90	50	70	—	—
Hard. & Temp	35–75	45–50	20–60	10	30–50
Endurance Limit (annealed), 1000 psi	40	45	40	40	45
Creep Str (1% ext in 10,000 hr, annealed), psi					
1000 F	9200	—	9200	—	—
1300 F	1000	—	1000	—	—
THERMAL TREATMENT					
Annealing Temp, F	1500–1650	—	1500–1650	1550–1650	—
Hardening Temp, F	1700–1850	1800–1900	1700–1850	1800–1900	1800–1950
Tempering Temp, F	400–1400	400–1300	400–1400	300–700	400–1200
FABRICATING PROPERTIES					
Machinability	Fair	Poor	Good; 80% of screw stock	Fair	Poor
Weldability	Fair; small welds can be annealed	Poor	Poor	Fair	Poor
Forging Temp (start), F	2000–2200	2100–2200	2100–2300	2000–2200	2100–2250
CORROSION RESISTANCE	Good resistance to weather and water; also good resistance to some chemicals				
AVAILABLE FORMS	Plate, sheet, strip, bar, tube, rounds, structural and bar shapes, round and flat wire, tubing				
USES	Steam turbine blades, highly stressed parts	Springs, knife blades, tempered rules	Automatic screw machine parts	Cutlery, surgical instruments, ball bearings, magnets	High strength parts

Martensitic Stainless Steels—concluded

AISI Type →	440A	440B	440C	501	502
COMPOSITION, %	C 0.60–0.75, Cr 16–18, Mo 0.75 max	C 0.75–0.95, Cr 16–18, Mo 0.75 max	C 0.95–1.20, Cr 16–18, Mo 0.75 max	C > 0.10, Cr 4–6	C 0.10 max, Cr 4-6
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.28	0.28	0.28	0.28	0.28
Melting Point, F	2500–2750	2500–2750	2500–2750	2700–2800	2700–2800
Ther Cond (212 F), Btu/hr/sq ft/°F/ft.	14.0	14.0	14.0	21.2	21.2
Coef of Ther Exp, per °F					
32–212 F	5.6×10^{-6}	5.6×10^{-6}	5.6×10^{-6}	6.2×10^{-6}	6.2×10^{-6}
32–1200 F	—	—	—	7.3×10^{-6}	7.3×10^{-6}
Spec Ht (32–212 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (rm temp), microhm-cm	60	60	60	40	40
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6	29.0×10^6
Ten Str, 1000 psi					
Annealed	105	107	110	70	65–70
Hard. & Temp	260	280	285	115–175	—
Yld Str, 1000 psi					
Annealed	60	62	65	30	25–30
Hard. & Temp	240	270	275	90–135	—
Elong (in 2 in.), %					
Annealed	20	18	14	28	30
Hard. & Temp	5	3	2	15–20	—
Hardness (Brinell)					
Annealed	215	220	230	160	150
Hard. & Temp	510	555	580	240–370	—
Impact Str (Izod), ft-lb					
Annealed	2	2	2	—	85
Hard. & Temp	4	3	2	—	—
Endurance Limit (annealed), 1000 psi	40	40	40	35	35
Creep Str (1% ext in 10,000 hr, annealed), psi					
1000 F	Not used in fatigue applications			9500	9500
1300 F				800	800
THERMAL TREATMENT					
Annealing Temp, F	1550–1650	1550–1650	1550–1650	1525–1600	1525–1600
Hardening Temp, F	1850–1950	1850–1950	1850–1950	1600–1700	—[a]
Tempering Temp, F	300–800	300–800	300–800	400–1400	—[a]
FABRICATING PROPERTIES					
Machinability	Fair	Fair	Fair	—	—
Weldability	Welding not generally recommended	Welding not generally recommended	Welding not recommended	—	—
Forging Temp (start), F	1900–2200	1900–2150	1900–2100	—	—
CORROSION RESISTANCE	Good resistance to weather and water; also good resistance to some chemicals				
AVAILABLE FORMS	Plate, sheet, strip, bar, tube, rounds, structural and bar shapes, round and flat wire, tubing				
USES	Instruments, cutlery, valves			Applications requiring heat resistance and good mechanical properties at elevated temperatures	

[a]Generally used in annealed condition only.

Ferritic Stainless Steels

AISI Type ➡	405	430	430F	446
COMPOSITION, %[a]	C 0.08, Mn 1.00, Si 1.00, P 0.04, S 0.03, Cr 11.5–14.5, Al 0.10–0.30	C 0.12, Mn 1.00, Si 1.00, P 0.04, S 0.03, Cr 14.0–18.0	C 0.12, Mn 1.25, P 0.06, S 0.15 min, Cr 14.0–18.0	C 0.20, Mn 1.50, Si 1.00, P 0.04, S 0.03, Cr 23.0–27.0, N 0.25
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.28	0.28	0.28	0.27
Melting Temp Range, F	2700–2790	2600–2750	2600–2750	2600–2750
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	15.1	15.1	12.1
Coef of Ther Exp (32–212 F), per °F	6.0×10^{-6}	5.8×10^{-6}	5.8×10^{-6}	5.8×10^{-6}
Spec Ht, Btu/lb/°F	0.11	0.11	0.11	0.12
Elec Res (70 F), microhm-cm	60.0	60.0	60.0	67.0
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6	29×10^6
Ten Str, 1000 psi				
Annealed	65–70	75	80	80–85
Cold Worked	85	75–90	80–90	85
Yld Str (0.2% offset), 1000 psi				
Annealed	35–40	40–45	55	50–55
Cold Worked	70	45–80	55–80	70
Elong (in 2 in.), %				
Annealed	25–30	25–30	25	20–25
Cold Worked	20	15–25	15–25	20
Red. of Area, %				
Annealed	50–60	60–65	60–65	45
Cold Worked	60	55–65	55–65	45
Hardness (Rockwell)				
Annealed	B75–90	B80	B80	B83–B86
Cold Worked	185[b]	B95	B95	B90
Impact Str (Izod, annealed), ft-lb	25[c]	—	—	2
Creep Str (1%, 1000 F), 1000 psi				
10,000 Hr	—	8.5	8.5	6.0
100,000 Hr	—	7.0	7.0	4.2
THERMAL TREATMENT				
Annealing Temp, F	1350–1500	1400–1500	1250–1400	1450–1600
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1950–2050	1900–2050	1950–2100	1950–2050
Machinability	Good	Fair	Excellent	Fair
Weldability	Excellent for fusion welding	Fair; welds are brittle	Not recommended	Fair; great care required because of high Cr content
CORROSION RESISTANCE	Good resistance to weather, water, some chemicals	Excellent resistance to weather, water; good resistance to most chemicals	Very good resistance to weather, water; some resistance sacrificed for better machinability	High resistance to corrosion and scaling; one of the most oxidation resistant steels commercially available
AVAILABLE FORMS	Bar, plate, sheet	Bar, plate, sheet, strip	Bar	Bar, plate, sheet, strip
USES	Lining for oil stills; weldments where 12% Cr gives sufficient corrosion resistance	General purpose grade; substitute for type 302; automobile and other trim, kitchen equipment, chemical equipment (430F is free-machining grade)		High temperature service up to 2150 F. Furnace parts, glass molds, pyrometer tubes, chemical processing equipment

[a] Maximum values unless otherwise stated. [b] Brinell. [c] Minimum.

Age Hardening Stainless Steels

Type →	Stainless W	17-4PH	Cast 17-4PH	17-7PH	AM350
COMPOSITION, %	C 0.07, Cr 17, Ni 7, Ti 0.70, Al 0.20	C 0.04, Cr 16.5, Ni4, Cu 4, Cb & Ta 0.35	C 0.07, max, Cr 15.75–16.75, Ni 3.50–4.25, Cu 3.50–4.25, N 0.045 max	C 0.07, Cr 17, Ni 7, Al 1.10	C 0.07, Cr 17, Ni 4, Mo 2.75
PHYSICAL PROPERTIES[a]					
Density, lb/cu in.	0.280	0.281	0.280	0.276	0.290
Ther Cond (212–300 F), Btu/hr/sq ft/°F/ft	10.0	10.4	10.4	9.7	—
Coef of Ther Exp (70–200 F), per °F	5.5 x 10^{-6} [b]	6.0 x 10^{-6}	6.0 x 10^{-6}	6.2 x 10^{-6}	9.0 x 10^{-6} [c]
Elec Res (68 F), microhm-cm	100	98	98	86.5	70.97
Magnetic Perm (max)	101	151	95	111	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	28.3 x 10^6	28.5 x 10^6	28.5 x 10^6	29.5 x 10^6	28.0 x 10^6
Ten Str, 1000 psi					
Sol'n Treated	135	150	152	130	186
Aged[d]	210[e], 190[f]	195[g], 161[h]	170[i], 130[j]	215[k], 200[l]	199[m], 189[n]
Yld Str (0.2% offset), 1000 psi					
Sol'n Treated	95	110	83	40	52
Aged[d]	195[e], 170[f]	180[g], 155[h]	140[i], 100[j]	200[k], 185[l]	159[m], 163[n]
Elong (in 2 in.), %					
Sol'n Treated	7	12	5	30	22
Aged[d]	7[e], 8[f]	13[g], 15[h]	6[i], 12[j]	8[k], 9[l]	11[m], 15[n]
Hardness (Rockwell)					
Sol'n Treated	C25	C32	C41	B85	B94
Aged[d]	C43[e], C39[f]	C42[g], C35[h]	390[i,p], 310[j,p]	C45[k], C43[l]	C41[m], C41[n]
Rupture Stress (1000 hr), 1000 psi					
700 F	—	130[g]	130[g]	138[k]	—
800 F	—	89[g]	89[g]	100[k]	161[m]
900 F	—	48[g]	—	57[k]	99[m]
Creep Str (1000 hr, 700 F), 1000 psi					
0.1%	—	—	120	135[k]	—
0.01%	—	—	80	105[k]	—
THERMAL TREATMENT					
Solution Temp, F	1850–1950	1875–1925	1800–1850	1800–1850	1700–1750
Final Aging Temp, F	950–1050	900–1000	850–900	950–1050	850
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1700–2300	1800–2200	—	To 2150	1800–2350
Machinability	Slightly easier to machine than type 302	Similar to type 410 (280–320 Bhn)	Similar to type 410 (280–320 Bhn)	Not often machined	Similar to type 302
Weldability	Readily weldable by arc and resistance processes applicable to stainless steels				
CORROSION RESISTANCE	Not outstanding; suitable for conditions met by cold rolled type 301. Not subject to intergranular embrittlement. AM350: superior compared to other hardenable stainless steels. Cast 17-4PH: good resistance to sea water corrosion				
AVAILABLE FORMS	Bars, forging billets, plate	Bars, forging billets, wire	Castings	All wrought forms	Bar, wire, sheet, strip, plate
USES	Used where high strength-weight ratio, corrosion resistance, and good strength at moderate temperatures are required		Chemical equipment needing strength, galling resistance	Used where high strength-weight ratio, corrosion resistance, and good strength at moderate temperatures are required	

[a] Condition is sol'n treated except 17-7PH which is precipitation hardened. [b] 32–212 F. [c] 70–1000 F.

[d] Treatment as indicated here:

1. Sol'n treated, aged at following temp and air cooled: [e]950 F; [f]1050 F; [g]900 F; [h]1100 F; [i]875 F (min value); [j]1050 F (min value).
2. Sol'n treated, transformed (1400 F) and air cooled, aged at following temp and air cooled: [k]950 F; [l]1050 F.
3. Sol'n treated, subzero cooled at −100 to −130 F, tempered 2 hr at following temp: [m]750 F; [n]950 F.

[p] Brinell.

Cast Carbon Steels

Class[a] →	60,000	65,000	70,000	80,000	85,000	100,000
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}	8.3×10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	13–16	13–16	13–16	13–16	13–16	13–16
Magnetic?	Yes	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[b]						
Mod of Elast in Tension, psi	30.1×10^6	30.1×10^6	30×10^6	29.9×10^6	29.9×10^6	29.7×10^6
Ten Str, 1000 psi	60[c]	65[d]	70[d]	80[e]	85[e]	100[f]
Yld Point, 1000 psi	30[c]	35[d]	38[d]	45[e]	50[e]	70[f]
Elong (in 2 in.), %	32[c]	30[d]	28[d]	26[e]	24[e]	20[f]
Red. of Area, %	55[c]	53[d]	50[d]	43[e]	40[e]	46[f]
Hardness (Brinell)	120[c]	130[d]	140[d]	160[e]	175[e]	200[f]
Impact Str (Izod), ft-lb						
70 F	30[c]	30[d]	30[d]	25[e]	20[e]	30[f]
−50 F	8[c]	12[d]	10[d]	12[e]	10[e]	15[f]
Endurance Limit, 1000 psi	25[c]	28[d]	31[d]	35[e]	38[e]	47[f]
THERMAL TREATMENT						
Annealing Temp, F	About 200 F above critical range					
Quenching Temp, F	About 100 F above critical range					
FABRICATING PROPERTIES						
Machinability Index[g]	55	60	65	70	70	65
Weldability	Can be welded by procedures used for welding wrought steels of similar composition					
CORROSION RESISTANCE	When brought into contact with moisture and air, carbon steels rust at rates that are not affected by carbon content. If salts are present, corrosion rate is increased. Attacked readily by acids, but resistant to alkalis at ordinary temperatures					
USES	Applications requiring low electrical resistivity, good magnetic properties, carburizing and case hardening, weldability	Applications requiring excellent weldability; medium strength with good machinability and high ductility	Applications requiring high strength with good machinability, toughness and excellent fatigue resistance	Applications requiring wear resistance and hardness		

[a]Tensile strength, psi.
[b]Normally expected values for steel castings having tensile strength given.
[c]Annealed.
[d]Normalized.
[e]Normalized and tempered.
[f]Quenched and tempered.
[g]Based on AISI B1112 steel = 100.

Cast Low Alloy Steels[a]

Class[b] →	70,000	80,000	90,000	100,000	110,000
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	15–20	15–20	15–20	15–20	15–20
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[c]					
Mod of Elast in Tension, psi	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6
Ten Str, 1000 psi	70[e]	80[e]	90[e]	100[e]	110[f]
Yld Point, 1000 psi	45	50	60	68	85
Elong (in 2 in.), %	26	24	22	20	20
Red. of Area, %	56	50	46	42	45
Hardness (Brinell)	150	170	190	209	235
Impact Str (Charpy), ft-lb					
70 F	35	30	26	22	23
–50 F	25	20	15	12	18
Endurance Limit, 1000 psi	33	38	41	45	49
THERMAL TREATMENT					
Annealing Temp, F	About 200 F above critical range				
Quenching Temp, F	About 100 F above critical range				
FABRICATING PROPERTIES					
Machinability Index[d]	65	70	70	65	60
Weldability	Can be welded by procedures used for wrought steels of similar composition				
CORROSION RESISTANCE	Similar to corrosion resistance of carbon steels				
USES	Applications requiring excellent weldability; medium strength with high toughness and good machinability; good high temperature properties		Applications requiring toughness or excellent high temperature and deep hardening properties		Applications requiring high resistance to impact; excellent low temperature properties; deep hardening; or excellent combination of strength and toughness

[a]Below 8% total alloy content.
[b]Tensile strength, psi.
[c]Normally expected values for steel castings having tensile strength given.
[d]Based on AISI B1112 steel = 100.
[e]Normalized and tempered.
[f]Quenched and tempered.

continued

Cast Low Alloy Steels—concluded

Class[b] →	120,000	150,000	175,000	200,000
PHYSICAL PROPERTIES				
Density, lb/cu in	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	27	27	27	27
Coef of Ther Exp (70–1200 F), per °F	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}	8.0–8.3 x 10^{-6}
Spec Ht, Btu/lb/°F	0.10–0.11	0.10–0.11	0.10–0.11	0.10–0.11
Elec Res (68 F), microhm-cm	15–20	15–20	15–20	15–20
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES[c]				
Mod of Elast in Tension, psi	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6	29–30 x 10^6
Ten Str, 1000 psi	120[f]	150[f]	175[f]	200[f]
Yld Point, 1000 psi	95	125	148	170
Elong. (in 2 in.), %	16	12	8	5
Red. of Area, %	38	25	20	11
Hardness (Brinell)	245	300	340	400
Impact Str (Charpy), ft-lb				
70 F	20	14	10	—
–50 F	16	10	6	—
Endurance Limit, 1000 psi	55	65	77	85
THERMAL TREATMENT				
Annealing Temp, F	About 200 F above critical range			
Quenching Temp, F	About 100 F above critical range			
FABRICATING PROPERTIES				
Machinability Index[d]	50	30	—	—
Weldability	Can be welded by procedures used for wrought steels of similar composition			
CORROSION RESISTANCE	Generally similar to carbon steels			
USES	Applications requiring high resistance to impact, excellent low temperature properties, deep hardening; excellent combination of strength and toughness	Applications requiring deep hardening, high strength, wear resistance, fatigue resistance	Applications requiring high strength, wear resistance, high hardness, high fatigue resistance	

[a]Below 8% total alloy content.
[b]Tensile strength, psi.
[c]Normally expected values for steel castings having tensile strength given.
[d]Based on AISI B1112 steel = 100.
[f]Quenched and tempered.

Cast Stainless Steels

ACI Type →	CA-15	CA-40	CB-30	CC-50
COMPOSITION, %	Cr 11.5–14.0, Ni 1.0 max, C 0.15 max, Mn 1.0 max, Si 1.5 max	Cr 11.5–14.0, Ni 1.0 max, C 0.20–0.40, Mn 1.00 max, Si 1.50 max	Cr 18–22, Ni 2.0 max, C 0.30 max, Mn 1.00 max, Si 1.00 max	Cr 26–30, Ni 4.0 max, C 0.50 max, Mn 1.0 max, Si 1.0 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.275	0.275	0.272	0.272
Melting Point, F	2750	2725	2725	2725
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	14.5	14.5	12.8	12.6
Coef of Ther Exp (70–1000 F), per °F	6.4×10^{-6}	6.4×10^{-6}	6.5×10^{-6}	6.4×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.11	0.11	0.12
Elec Res (70 F), microhm-cm	78	76	76	77
Magnetic?	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	29×10^6	29×10^6	29×10^6	29×10^6
Ten Str, 1000 psi				
Annealed	—	—	95[d]	97[e]
As Cast	—	—	—	70–95
Hard. & Temp	200[a], 100[b]	220[a], 110[c]	—	—
Yld Str (0.2% offset), 1000 psi				
Annealed	—	—	60[d]	65[e]
As Cast	—	—	—	60–65
Hard. & Temp	150[a], 75[b]	165[a], 67[c]	—	—
Elong (in 2 in.), %				
Annealed	—	—	15[d]	18[e]
As Cast	—	—	—	2–15
Hard. & Temp	7[a], 30[b]	1[a], 18[c]	—	—
Hardness (Brinell)				
Annealed	—	—	195[d]	210[e]
As Cast	—	—	—	193–212
Hard. & Temp	390[a], 185[b]	470[a], 212[c]	—	—
Impact Str (Charpy, keyhole notch), ft-lb				
Annealed	—	—	2[d]	—
As Cast	—	—	—	2–45 (Izod V notch)
Hard. & Temp	15[a], 35[b]	1[a], 3[c]	—	—
THERMAL TREATMENT				
Annealing Temp, F[f]	1450–1650 f.c.	1450–1650 f.c.	1450 f.c. and 1000 a.c.	1450 f.c. or a.c.
Hardening Temp, F[f]	1800–1850 a.c. or o.q.	1800–1850 a.c. or o.q.	Practically nonhardenable by heat treatment	Nonhardenable by heat treatment
Tempering Temp, F	< 600 or 1100–1500. Highest strength by tempering below 600		—	—
FABRICATING PROPERTIES				
Castability	Section thicknesses from 3/16 in. up can be cast satisfactorily. Somewhat lighter sections can be cast in some parts. Difficult-to-run thin sections and designs involving appreciable changes in section should be avoided. Normal shrinkage for these alloys is 1/4 in. per ft, except CC-50 which shrinks 7/32 in. per ft			
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance resulting from carbon pickup. Castings should be preheated and postheated			
CORROSION RESISTANCE	Good atmospheric corrosion resistance. Excellent resistance to many organic media in relatively mild service		Resists nitric acid, alkaline solutions, many organic chemicals, oxidizing atmospheres up to 1400 F	Excellent resistance to dilute sulfuric acid in mine waters, mixed nitric and sulfuric acids, and oxidizing acids of all types
USES	Pump casing, bushings and liners, impellers, shafts, turbine blades, stuffing boxes; valve bodies and trim, furnace burner tips	Choppers, cutting blades, cylinder liners, pump parts, steam turbine parts, molds and dies	Furnace brackets and hangers, pump parts, rabble arms, tube supports, valve bodies and parts	Bushings, cylinder liners, pump casings and impellers, valve bodies and seats

[a]Air cooled from 1800 F, tempered at 600 F.
[b]Air cooled from 1800 F, tempered at 1450 F.
[c]Air cooled from 1800 F, tempered at 1400 F.
[d]Annealed at 1450 F, furnace cooled to 1000 F, air cooled.
[e]Air cooled from 1900 F.
[f]f.c. = furnace cool, a.c. = air cool, o.q. = oil quench.

continued

Cast Stainless Steels—continued

ACI Type →	CE-30	CF-8	CF-20	CF-8M, CF-12M	CF-8C
COMPOSITION, %	Cr 26–30, Ni 8–11, C 0.30 max, Mn 1.50 max, Si 2.00 max	Cr 18–21, Ni 8–11, C 0.08 max, Mn 1.50 max, Si 2.00 max	Cr 18–21, Ni 8–11, C 0.20 max, Mn 1.50 max, Si 2.00 max	Cr 18–21, Ni 9–12, Mo 2.0–3.0, C 0.08 (CF-8M) or 0.12 (CF-12M), Mn 1.50 max, Si 2.00 max	Cr 18–21, Ni 9–12, Cb 1.0 max[g], C 0.08 max, Mn 1.50 max, Si 2.00 max
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.277	0.280	0.280	0.280	0.280
Melting Point, F	2650	2600	2575	2550	2600
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	9.2	9.2	9.4	9.3
Coef of Ther Exp (70–1000 F), per °F	9.6×10^{-6}	10.0×10^{-6}	10.4×10^{-6}	9.7×10^{-6}	10.3×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.14	0.12	0.12	0.12	0.12
Elec Res (70 F), microhm-cm	85	76	78	82	71
Magnetic Permeability	>1.5	1.0–1.3[j]	1.01	1.50–2.50	1.20–1.80
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	25×10^6	28×10^6	28×10^6	28×10^6	28×10^6
Ten Str, 1000 psi					
As Cast	95	—	—	—	—
Water Quenched[h]	97	77	77	80	77
Yld Str (0.2% offset), 1000 psi					
As Cast	60	—	—	—	—
Water Quenched[h]	63	37	36	42	38
Elongation (in 2 in.), %					
As Cast	15	—	—	—	—
Water Quenched[h]	18	55	50	50	39
Hardness (Brinell)					
As Cast	170	—	—	—	—
Water Quenched[h]	170	140	163	156–170	149
Impact Str (Charpy keyhole notch, water quenched[h]), ft-lb	—	74	60	70	30
FABRICATING PROPERTIES					
Castability	Section thicknesses from 3/16 in. up can be cast satisfactorily. Somewhat lighter sections are also possible in some parts. Good castability of these alloys permits designs involving intricate shapes, but drastic changes in section should be avoided and uniform thickness should be maintained as far as possible				
Quenching Temp, F[i]	1950–2050	1950–2050	2000–2100	1950–2100	1950–2050
Weldability	Can be welded by metal arc, inert-gas arc and oxyacetylene gas methods. Metal arc most frequently used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance caused by carbon pickup. Preheating not necessary, but castings should be quenched from the range 1950 to 2100 F to restore maximum corrosion resistance. This heat treatment is not always necessary, however with CE-30 and CF-8C alloys				
CORROSION RESISTANCE	Particularly resistant to sulfurous acid, mixtures of dilute sulfuric and sulfurous acids, sulfuric and nitric acids, and sulfites	Resists strongly oxidizing media such as boiling nitric acid, sulfuric acid and sulfates, and organic acids	Similar to CF-8 but used under less drastic conditions	Resists reducing media. More resistant to pitting corrosion than CF-8 in contact with chlorides. Not as resistant to boiling nitric acid as CF-8	Similar to CF-8
USES	Process equipment such as digester fittings, fractionating towers, piping, pump bodies and casings, valve bodies and parts	Autoclaves, blast furnaces, bushings, filter press plates, hardware, headers and heating coils, pump parts, spray nozzles, valve parts	Cylinder liners, pumps, return bends, rolls, circuit breaker parts, valve parts	Agitators, evaporator parts, jet engine components, spray nozzles, high pressure steam valves	Aircraft shroud assemblies, autoclaves, chemical tubing, fittings, jet engine parts, marine fittings

[g]Minimum is eight times carbon content.
[h]Water quenched from 2000 F.
[i]Water, oil or air quench.
[j]After heat treatment.

Cast Stainless Steels—concluded

ACI Type ➡	CF-16F	CH-20	CK-20	CN-7M
COMPOSITION, %	Cr 18–21, Ni 9–12, C 0.16 max, Mo 1.50 max, Se 0.20–0.35, Mn 1.50 max, Si 2.00 max	Cr 22–26, Ni 12–15, C 0.20 max, Mn 1.50 max, Si 2.00 max	Cr 23–27, Ni 19–22, C 0.20 max, Mn 1.50 max, Si 2.00 max	Cr 19–22, Ni 27.5–30.5, Mo 1.75–2.50, Cu 3.00 min, C 0.07 max, Mn 1.50 max, Si 1.50 max
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.280	0.279	0.280	0.289
Melting Point, F	2550	2600	2600	2650
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.4	8.2	8.2	12.1
Coef of Ther Exp (70–1000 F), per °F	9.9×10^{-6}	9.6×10^{-6}	9.2×10^{-6}	9.7×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12	0.12	0.12	0.11
Elec Res (70 F), microhm-cm	72	84	90	90
Magnetic Permeability	1.0–2.0	1.71[j]	1.02	1.01–1.10
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	28×10^6	28×10^6	29×10^6	24×10^6
Ten Str, 1000 psi[h]	77	88	76	69
Yld Str (0.2% offset), 1000 psi[h]	40	50	38	31
Elong (in 2 in.), %[h]	52	38	37	48
Hardness (Brinell)[h]	150	190	144	130
Impact Str (Charpy, keyhole notch), ft-lb[h]	75	30	46 (Izod V notch)	70
FABRICATING PROPERTIES				
Castability	Section thicknesses from 3/16 in. up can be cast satisfactorily. Somewhat lighter sections are also possible on some parts. Good castability permits designs involving intricate shapes, but drastic changes in section should be avoided			
Quenching Temp, F[i]	2000–2100	2000–2100	2000–2150	1950–2050
Weldability	Can be welded by metal arc, inert-gas arc, and oxyacetylene gas methods. Metal arc welding most used. Oxyacetylene welding not advisable because of possible reduction in corrosion resistance resulting from carbon pickup			
	Preheating not necessary, but castings should be quenched from 2000–2100 F to restore maximum corrosion resistance			Preheating at 400 F necessary. After welding, castings should be quenched from 2000 F
CORROSION RESISTANCE	Similar to but somewhat inferior to CF-8	Resistant to hot dilute sulfuric acid. Superior to CF-8 in certain media	Similar to CH-20, but better resistance at elevated temperatures	Resists sulfuric acid and many reducing chemicals. Good resistance to dilute hydrochloric acid and salt solutions
USES	Bearings, bushings, fittings, pump and machinery parts	Digester fittings, roasting equipment, valves, pump parts	Digesters, filter press parts, fittings, jet engine parts, pumps, valves	Filter parts; heat exchanger parts; pickling rolls, hooks, racks and tanks; valve parts

[h] Water quenched from 2000 F.
[i] Water, oil or air quench.
[j] After heat treatment.

Cast Heat Resistant Alloys

ACI Type →	HA	HC	HD	HE	HF
COMPOSITION, %	C 0.20 max, Mn 0.35-0.65, Si 1.00 max, P 0.04 max, S 0.04 max, Mo 0.90- 1.20, Cr 8-10	C 0.50 max, Mn 1.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 26-30, Ni 4 max	C 0.50 max, Mn 1.50 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 26-30, Ni 4-7	C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 26-30, Ni 8-11	C 0.20-0.40, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 19-23, Ni 9-12
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.279	0.272	0.274	0.277	0.280
Melting Point, F	2750	2725	2700	2650	2550
Ther Cond (212 F), Btu/hr/sq ft/ft/°F	15.2	12.6	12.6	10.0[b]	9.0
Coef of Ther Exp (70–1200 F), per °F	7.5 x 10^{-6}	6.4 x 10^{-6}	8.0 x 10^{-6}	9.9 x 10^{-6}	10.1 x 10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.12	0.12	0.14	0.12
Elec Res (70 F), microhm-cm	70	77	81	85	80
Magnetic Permeability	Ferromagnetic	Ferromagnetic	Ferromagnetic	1.3-2.5	1.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	29 x 10^6	29 x 10^6	27 x 10^6	25 x 10^6	28 x 10^6
Ten Str, 1000 psi[a]	95[d], 107[b]	70–110, 115[c]	85, —	95, 90[c]	85, 100[c]
Yld Str (0.2% offset), 1000 psi[a]	65[d], 81[b]	65–75, 80[c]	48, —	45, 55[c]	45, 50[c]
Elong (2 in.), %[a]	23[d], 21[b]	2–19, 18[c]	16, —	20, 10[c]	35, 25[c]
Hardness (Brinell)[a]	180[d], 220[b]	190–223, —	190, —	200, 270[c]	165, 190[c]
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi	67 (1000 F), 44 (1100 F)	—	36 (1400 F), 23 (1600 F), 15 (1800 F)	—	57 (1200 F), 35 (1400 F), 22 (1600 F)
Yld Str (0.2% offset), 1000 psi	42 (1000 F), 32 (1100 F)	—	—	—	21 (1400 F)
Elong (2 in.), %	36 (1100 F)	—	14 (1400 F), 18 (1600 F), 40 (1800 F)	—	16 (1200 F), 20 (1400 F), 22 (1600 F)
Creep Str (0.0001%/hr), 1000 psi	16 (1000 F), 7.2 (1100 F), 3.1 (1200 F)	1.3 (1400 F), 0.75 (1600 F), 0.36 (1800 F)	3.5 (1400 F), 1.9 (1600 F), 0.9 (1800 F)	4.0 (1400 F), 2.4 (1600 F), 1.4 (1800 F)	13 (1200 F), 6.0 (1400 F), 3.2 (1600 F)
Rupture Str, 1000 psi					
10 Hr	45 (1000 F)	4.6 (1400 F), 2.0 (1600 F), 1.1 (1800 F)	14 (1400 F)	—	37 (1200 F), 20 (1400 F), 10 (1600 F)
100 Hr	37 (1000 F)	3.3 (1400 F), 1.7 (1600 F), 0.85 (1800 F)	10 (1400 F), 5 (1600 F), 2.5 (1800 F)	11 (1400 F), 5.3 (1600 F), 2.5 (1800 F)	30 (1200 F), 14 (1400 F), 6.0 (1600 F)
1000 Hr	27 (1000 F)	2.3 (1400 F), 1.3 (1600 F), 0.62 (1800 F)	7 (1400 F)	—	17 (1200 F), 8.0 (1400 F), 3.8 (1600 F)
FABRICATING PROPERTIES					
Annealing Temp, F	1625	—	—	—	1900[e]
Machinability	Fair	Good	Good	Good	Good
Weldability	Weldable by all common methods. Preheating, postheating desirable		Weldable by all common methods. Preheating not required		
USES	Fan blades, furnace rollers, lehr rolls, refinery fittings, trunnions	Grate bars, dampers, kiln parts, rabble blades, salt pots, tuyeres	Brazing furnace parts, cracking equipment, furnace blowers, pouring spouts, salt pots, gas burner parts	Billet skids, burner nozzles, furnace conveyors, tube supports, soot blower elements	Electrode arms, burner tips, annealing boxes, wear plates, gas burner rings, conveyor belts, dampers

[a]As cast and heat treated values given in that order. [b]Normalized at 1825 F, tempered at 1250 F.
[c]Aged 24 hr at 1400 F, furnace cooled. [d]Annealed. [e]Before cyclic temperature service. 6 hr at 1900 F may improve life. [f]At 1500 F.

Cast Heat Resistant Alloys—continued

ACI Type →	HH		HI	HK	HL
COMPOSITION, %	C 0.20-0.50, Cr 24-48, Mn 2.00 max, Ni 11-14, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, N 0.2 max		C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 26-30, Ni 14-18	C 0.20-0.60, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 24-28, Ni 18-22	C 0.20-0.60, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 28-32, Ni 18-22
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.279		0.279	0.280	0.279
Melting Point, F	2500		2550	2550	2600
Ther Cond (212F), Btu/hr/sq ft/ft/°F	8.2		10.9	8.2	8.2
Coef of Ther Exp (70–1800 F), per °F	10.5×10^{-6}		10.5×10^{-6}	10.0×10^{-6}	9.9×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.12		0.12	0.12	0.12
Elec Res (70 F), microhm-cm	75-85		—	90	94
Magnetic Permeability	1.0-1.9		1.0-1.7	1.02	1.01
MECHANICAL PROPERTIES	Type I[h]	Type II[i]			
Mod of Elast in Tension, psi	27×10^6	27×10^6	27×10^6	29×10^6	29×10^6
Ten Str, 1000 psi[g]	80, 86	85, 92	80, 90	75, 85	82, —
Yld Str, 1000 psi[g]	50, 55	40, 45	45, 65	50, 50	52, —
Elong (2 in.), %[g]	25, 11	15, 8	12, 6	17, 10	19, —
Hardness (Brinell)[g]	185, 200	180, 200	180, 200	170, 190	192, —
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi					
1400 F	33	35	38	—	50
1600	18.5	22	26	23	30
1800 F	9.0	11	→	—	19
Yld Str (0.2% offset), 1000 psi					
1400 F	17	18	—	—	—
1600 F	13.5	14	—	—	—
1800 F	6.3	7.0	—	—	—
Elong (2 in.), %					
1400 F	18	12	6	—	—
1600 F	30	16	12	21	—
1800 F	45	30	—	—	—
Creep Str (0.0001% hr), 1000 psi					
1400 F	3.0	7.0	6.6	6.8	7.0
1600 F	1.7	4.0	3.6	4.2	4.3
2001 F	0.3	0.8	0.8	1.0	—
2150 F	—	—	0.15	0.2	—
Rupture Str, 1000 psi					
10 Hr, 1400 F	—	20	—	23	—
10 Hr, 1600 F	—	10	—	11	—
10 Hr, 1800 F	4.7	6.0	—	6.5	—
100 Hr, 1400 F	14	14	13	14.5	15
100 Hr, 1600 F	6.4	7.5	7.5	7.8	9.2
100 Hr, 2000 F	1.5	1.8	1.9	2.5	—
1000 Hr, 1400 F	6.5	10	8.5	9.0	—
1000 Hr, 1600 F	3.8	4.7	4.8	5.0	—
1000 Hr, 2000 F	—	1.2	1.2	—	—
FABRICATING PROPERTIES					
Annealing Temp, F	1900[d]	1900[d]	—	—	—
Machinability	Fair	Fair	Fair	Good	Good
Weldability	Weldable by all common methods; no preheat or postheat required				
USES	Annealing trays, tube supports, carburizing boxes, exhaust manifolds, radiant tubes, retorts, stoker parts		Billet skids, brazing fixtures, furnace rails, lead pots, tube spacers, retorts	Heat treating fixtures, rabble arms, retorts, brazing fixtures, skid rails	Carrier fingers, enameling furnace fixtures, furnace skids, stack dampers

[d]Before cyclic temperature service. 6 hr at 1900 F may improve life.

[g]As cast and heat treated (aged 24 hr at 1400 F, furnace cooled) values given in that order. [h]Partially ferritic. [i]Austenitic.

continued

Cast Heat Resistant Alloys—concluded

ACI Type →	HN	HT	HU	HW	HX
COMPOSITION, %	C 0.20-0.50, Mn 2.00 max, Si 2.00 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 19-23, Ni 23-27	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 13-17, Ni 33-37	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 17-21, Ni 37-41	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 10-14, Ni 58-62	C 0.35-0.75, Mn 2.00 max, Si 2.50 max, P 0.04 max, S 0.04 max, Mo 0.5 max, Cr 15-19, Ni 64-68
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.286	0.290	0.294	0.294
Melting Point, F	2500	2450	2450	2350	2350
Ther Cond (212F), Btu/hr/sq ft/ft/°F	—	7.7	—	7.7	—
Coef of Ther Exp (70–1800 F), per °F	—	9.8×10^{-6}	9.6×10^{-6}	8.8×10^{-6}	9.2×10^{-6}
Spec Ht (70 F), Btu/lb/°F	0.11	0.11	0.11	0.11	0.11
Elec Res (70 F), microhm-cm	—	100	105	112	—
Magnetic Permeability	1.10	1.10-2.00	1.10-2.00	16.0	2.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	27×10^6	27×10^6	27×10^6	25×10^6	25×10^6
Ten Str, 1000 psi[a]	68, —	70, 75[j]	70, 73[k]	68, 84[l]	65, 73[k]
Yld Str, 1000 psi[a]	38, —	40, 45[j]	40, 43[k]	36, 52[l]	36, 44[k]
Elong (2 in.), %[a]	17, —	10, 5[j]	9, 5[k]	4, 4[l]	9, 9[k]
Hardness (Brinell)[a]	160, —	180, 200[j]	170, 190[k]	185, 205[l]	176, 185[k]
ELEVATED TEMPERATURE PROPERTIES					
Ten Str, 1000 psi					
1400 F	—	35	40	32	—
1600 F	—	18.8	19.6	19	20.5
1800 F	—	11	10.0	10	10.7
Yld Str (0.2% offset), 1000 psi					
1400 F	—	26	—	23	—
1600 F	—	15	—	15	17.5
1800 F	—	8.0	6.2	8.0	6.9
Elong (2 in.), %					
1400 F	—	10	—	—	—
1600 F	—	26	20	—	48
1800 F	—	28	28	40	40
Creep Str (0.0001%/hr), 1000 psi					
1400 F	—	8.0	8.5	6.0	6.4
1600 F	6.3	4.5	5.0	3.0	3.2
2000 F	0.9	0.5	0.6	—	0.6
2150 F	—	0.15	—	—	—
Rupture Str, 1000 psi					
10 Hr, 1400 F	—	—	—	16	18
10 Hr, 1600 F	—	11	—	8.2	10
10 Hr, 2000 F	—	—	—	—	2.5
100 Hr, 1400 F	—	18	15	10	13
100 Hr, 1600 F	9.5	8.5	8.0	6.0	6.7
100 Hr, 2000 F	2.5	2.5	—	—	1.7
1000 Hr, 1400 F	—	12.5	—	7.8	—
1000 Hr, 1600 F	6.5	7.0	6.0	4.5	4.0
1000 Hr, 2000 F	0.9	1.8	—	—	0.9
FABRICATING PROPERTIES					
Annealing Temp, F	—	1900[d]	1900[d]	—	—
Machinability	Good	Good	Good	Good	Good
Weldability	Weldable by all common methods; no preheat or postheat required				
USES	Brazing fixtures, chain, nozzles, furnace parts, radiant tubes, tube supports	Air ducts, carburizing boxes, cyanide pots, glass molds, lead pots	Articulated trays, burner tubes, lead pots, cyanide pots, muffles	Cyanide pots, gas retorts, electric heating elements, hearth plates	Autoclaves, calciner tubes, furnace parts, salt bath electrodes, muffles

[a]As cast and heat treated values given in that order.
[d]Before cyclic temperature service. 6 hr at 1900 F may improve life.
[j]Aged 24 hr at 1400 F, air cooled. [k]Aged at 1400 F, furnace cooled [l]Aged 48 hr at 1800 F, furnace cooled.

Nitriding Steels

Nitralloy Type →	135	135, Modified	N	EZ	GR
COMPOSITION, %	C 0.30–0.40, Mn 0.40–0.70, Si 0.20–0.40, Cr 0.90–1.40, Al 0.85–1.20, Mo 0.15–0.25	C 0.38–0.45, Mn 0.40–0.70, Si 0.20–0.40, Cr 1.40–1.80, Al 0.85–1.20, Mo 0.30–0.45	C 0.20–0.27, Mn 0.40–0.70, Si 0.20–0.40, Cr 1.00–1.50, Al 0.85–1.20, Mo 0.20–0.30, Ni 3.25–3.75	C 0.30–0.40, Mn 0.50–1.10, Si 0.20–0.40, Cr 1.00–1.50, Al 0.85–1.20, Mo 0.15–0.25, Se 0.15–0.25	C 1.25–1.50, Mn 0.40–0.60, Si 1.25–1.50, Cr 0.20–0.40, Al 1.00–1.50, Mo 0.20–0.30
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.283	0.283	0.283	0.283	0.283
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	30	30	30	30	30
Coef of Ther Exp (32–932 F), per °F	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}	6.5×10^{-6}
Spec Ht, Btu/lb/°F	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12	0.11–0.12
Elec Res (68 F), microhm-cm	27–29	27–29	27–29	27–29	27–29
Magnetic?	Yes	Yes	Yes	Yes	Yes
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$	$29–30 \times 10^6$
Ten Str (hard. & temp), 1000 psi	138[a], 121[b]	159[a], 145[b]	132[c], 190[d]	126[a]	108[e]
Yld Str (hard. & temp), 1000 psi	120[a], 103[b]	141[a], 125[b]	114[c], 180[d]	90[a f]	84[e]
Elong (in 2 in., hard. & temp), %	20[a], 23[b]	18[a], 20[b]	22[c], 15[d]	17[a]	17[e]
Red. of Area (hard. & temp), %	58[a], 62[b]	56[a], 64[b]	59[c], 43[d]	44[a]	19[e]
Hardness (Brinell, hard. & temp)	280[a], 230[b]	320[a], 285[b]	277[c], 415[d]	255[a]	—
	Cases produced by nitriding these steels will have hardnesses in the range Rockwell 15N 94 to 95, excepting case on Nitralloy N which will range from about Rockwell 15N 92 to 93				
Impact Str (Izod, hard. & temp), ft-lb	65[a], 80[b]	—	—	—	—
Endurance Limit, 1000 psi[g]	—	45[g1], 24[g2], 90[g3], 80[g4]	—	—	—
THERMAL TREATMENT					
Annealing Temp, F	1650–1700	1650–1700	1500–1550[h]	1650–1700	—
Quenching Temp, F	1700–1750	1700–1750	1625–1675	1700–1750	1625–1675
Tempering Temp, F	1100–1300	1100–1300	1100–1300	1100–1300	1100–1300
Nitriding Temp, F	930–1050 for periods ranging to 100 hr; 24 to 48-hr treatments are most widely used				
FABRICATING PROPERTIES					
Hot Working Temp Range, F	1950–2200	1950–2200	1950–2200	1950–2200	1950–2200
Weldability	Can be welded by atomic hydrogen process using Nitralloy welding rod; also flash welding				
CORROSION RESISTANCE	Provided the outer skin or white layer is not removed, the nitrided case is resistant to alkalis, crude oil, natural gas combustion products, tap water and unagitated salt water. Case is attacked by mineral acids. Removal of the white layer greatly reduces resistance to attack				
USES	Most uses based on resistance to wear. Cylinder liners and barrels in aircraft engines, bushings, shafts, piston pins, spindles and thread guides, cams and camshafts, rubber and paper mill rolls				

[a]Core properties; oil quenched from 1700 F, tempered at 1200 F.
[b]Core properties; oil quenched from 1700 F, tempered at 1300 F.
[c]Core properties; oil quenched from 1650 F, tempered at 1200 F, before nitriding.
[d]Core properties; oil quenched from 1650 F, tempered at 1200 F, after nitriding
[e]Core properties; oil quenched from 1650 F, tempered 5 hr at 1375 F.
[f]Proportional limit.
[g]Heat treated to 269 Bhn and tested (g1) unnitrided, unnotched; (g2) unnitrided with V notch; (g3) nitrided, unnotched; (g4) nitrided with V notch.
[h]Must be cooled rapidly below 1150 F to avoid precipitation hardening.

(Adv.)

Properties of ASTM PRESSURE VESSEL STEELS

	HIGH TEMPERATURE STEELS							
ASTM DESIGNATION	**A-204 Mo**			**A-387 (Supersedes A-301) Cr-Mo**				
	Grade A	**Grade B**	**Grade C**	**Grade A**	**Grade B**	**Grade C**	**Grade D**	**Grade E**
COMPOSITION, % based on 1" gage Firebox quality. (Values are max. unless otherwise indicated.)	C .18, Mn .90, P .035, S .04, Si .13-.32, Mo .41-.64	C .20, Mn .90, P .035, S .04, Si .13-.32, Mo .41-.64	C .23, Mn .90, P .035, S .04, Si .13-.32, Mo .41-.64	C .21, Mn .36-.84, P .035, S .040, Si .13-.32, Cr .46-.79, Mo .40-.70	C .17, Mn .36-.69, P .035, S .040, Si .13-.32, Cr .75-1.31, Mo .40-.70	C .17, Mn .36-.69, P .035, S .040, Si .48-1.02, Cr .94-1.56, Mo .40-.70	C .15, Mn .27-.63, P .035, S .040, Si .50, Cr 1.88-2.62, Mo .85-1.15	C .15, Mn .27-.63, P .035, S .040, Si .50, Cr 2.63-3.37, Mo .85-1.15
PHYSICAL PROPERTIES (c) Density, lb./cu. in.	0.283			0.283				
Magnetic Prop.	Magnetic. Some residual magnetism remains.			Magnetic. Some residual magnetism remains.				
PROCESS	Open Hearth or Electric Furnace			Open Hearth or Electric Furnace			Electric Furnace only	
MECHANICAL PROPERTIES	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. Annealed	Fbx. Annealed	Fbx. Annealed	Fbx. Annealed	Fbx. Annealed
Mod. of Elast. in Tension, psi	29-30x10⁶	29-30x10⁶	29-30x10⁶	29-30x10⁶	29-30x10⁶	29-30x10⁶	29-30x10⁶	29-30x10⁶
Tensile Strength, 1000 psi	65-77	70-85	75-90	65-82	60-82	60-85	60-85	60-85
Yield Point, 1000 psi min.	37	40	43	40	35	35	30(b)	30(b)
Elong. (in 2 inches), %	25	23	22	24	24	24	20	20
Red. of Area, % min.							50	50
Typical Hardness, Brinell(c)	140-165	150-180	165-200	140-175	135-175	135-180	135-180	135-180
Impact Str., Charpy Keyhole								
THERMAL TREATMENT	Over 2" gage requires grain refinement by normalizing. Under 2" may be as-rolled or stress-relieved, normalized, or normalized and stress-relieved.			All gages require grain refinement by either annealing, or normalizing and tempering. No quenching in liquid medium permitted.			All gages require annealing or normalizing and tempering.	
FABRICATING PROPERTIES(c) Formability	May be hot or cold formed.			May be hot or cold formed.				
Weldability	May be manual or machine welded. For all gages preheat and elevated interpass temperature are desirable. Stress relief desirable. Peening may be necessary for gages over 1 inch.			May be manual or machine welded. For gages under 4" preheat and elevated interpass temperature are desirable. Stress relief desirable. Peening may be necessary for gages over 1" thick.				
AVAILABLE FORMS	Plate form only. Flange quality to max. gage of 2" incl. Grades A and B, Fbx. quality to max. gage of 6" incl. Grade C, Fbx. quality to max. gage of 4" incl.			Plate form only. For Grades A, B and C Flange quality to max. gage of 2" incl., for Fbx. quality to max. gage of 6" incl. For Grades D and E to max. gage of 6" incl.				
USES	Boilers, other pressure vessels for service up to 1000°F inclusive.			Boilers, other pressure vessels. Grade A for service up to 1000°F, Grades B, C, D, & E for service up to 1200°F inclusive.				

ABBREVIATIONS: S.R., stress relieve; Fbx., firebox quality; Flg., Flange Quality

(a) Charpy Keyhole values are those required when specification made to ASTM A-300 specification.

(b) Values for these materials are yield strength (1000 psi, min.).

(c) Data or properties are not part of ASTM specifications.

Properties of LUKENS "T-1" CONSTRUCTIONAL ALLOY STEEL

(trademark)

"T-1" CONSTRUCTIONAL ALLOY STEEL

QUALITY	Composition, %	Mod. of Elast. in Tension, 1000 psi.	Tensile Strength 1000 psi (1" gage)	Yield Strength 1000 psi (1" gage)	Elong. in 2" Min. % (1" gage)	Reduction of Area, % (1" gage)	Typical Hardness Brinell	Impact Str. Charpy Keyhole	Thermal Treatment
REGULAR	C .10-.20, Mn .60-1.00, P .04, S .05, Si .15-.35, Ni .70-1.00, Cr .40-.80, Mo .40-.60, V .03-.10, Cu .15-.50, B .002-.006	30x10⁶	115-135	100 min.	18	50	250-280	—	Water quench and temper
321 MIN. BHN	same	same	—	—	—	—	321 min.	—	same
FLANGE	same	same	115-135	100 min.	18	50	250-280	—	same
FIREBOX	same*	same	115-135	100 min.	18	50	250-280	15 ft. lbs. at −50°F(a)	same
FIREBOX TO ASTM CASE 1204-3	same*	same	105-135	90 min.	17	—	250-280	15 ft. lbs. at −50°F(a)	same

*For Firebox quality, check analysis limit of P 0.035 max. and S 0.04 max. applies.

LOW TEMPERATURE STEELS							HIGH STRENGTH STEELS					
A-203 Ni					A-353 Low C, High Ni	A-410-57T Cr-Cu-Ni-Al	A-202 Cr-Mn-Si		A-225 Mn-V		A-302 Mg-Mo	
Grade A	Grade B	Grade C	Grade D	Grade E	—	—	Grade A	Grade B	Grade A	Grade B	Grade A	Grade B
C .17, Mn .80, P .035, S .04, Si .13-.32, Ni 2.13-2.67	C .20, Mn .80, P .035, S .04, Si .13-.32, Ni 2.13-2.67	C .25, Mn .80, P .035, S .04, Si .13-.32, Ni 2.13-2.67	C .17, Mn .80, P .035, S .04, Si .13-.32, Ni 3.18-3.82	C .20, Mn .80, P .035, S .04, Si .13-.32, Ni 3.18-3.82	C .13, Mn .80, P .035, S .040, Si .13-.32, Ni 8.40-9.60	C .12, Mn .55-1.00, P .040, S .040, Cu .40-.75, Si .08-.37, Ni .47-.98, Cr .44-1.01, Al .04-.30	C .17, Mn1.00-1.45, P .035, S .04, Si .54-.96, Cr .31-.64	C .25, Mn1.00-1.45, P .035, S .04, Si .54-.96, Cr .31-.64	C .18, Mn 1.45, P .035, S .04, Si .13-.32, V .07-.16	C .20, Mn 1.45, P .035, S .04, Si .13-.32, V .07-.16	C .20, Mn .90-1.35, P .035, S .040, Si .13-.32, Mo .41-.64	C .20, Mn1.10-1.55, P .035, S .040, Si .13-.32, Mo .41-.64
0.283 Magnetic. Some residual magnetism remains.					0.286 Magnetic. High residual magnetism remains.	0.283 Magnetic. Some residual magnetism remains.	0.283 Magnetic. Some residual magnetism remains.		0.283 Magnetic. Some residual magnetism remains.		0.283 Magnetic. High residual magnetism remains.	
Open hearth or electric furnace					Open hearth or electric furnace	Open hearth or electric furnace	Open hearth or electric furnace		Open hearth or electric furnace		Open hearth or electric furnace	
Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. Double Normalized	Fbx. Normalized	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled	Fbx. As Rolled
29-30x10⁶	29-30x10⁶	29-30x10⁶	29-30x10⁶	29-30x10⁶								
65-77	70-85	75-90	65-77	70-85	90 min.	60 min.	75-90	85-100	70-85	75-90	75-95	80-100
37	40	43	37	40	60 (b)	30	45	47	40	43	45	50
25	23	22	25	23	22	24	21	20	23	22	21	20
140-165	150-180	165-200	140-165	150-180	200	135	165-200	180-210	150-180	165-200	165-205	170-210
15 ft. lbs. at −75° F (a)			15 ft. lbs. at −150° F (a)		15 ft. lbs. at −320° F (a)	15 ft. lbs. at −150° F (a)						
Over 2″ gage requires grain refinement by normalizing. Under 2″ may be as-rolled or stress-relieved, normalized, or normalized and stress-relieved.					All gages require double normalizing.	All gages require grain refinement by normalizing.			Over 2″ gage requires grain refinement by normalizing. Under 2″ gage may be as-rolled, stress-relieved, normalized, or normalized and stress-relieved.		Over 2″ gage requires grain refinement by normalizing. Under 2″ gage may be as-rolled, stress-relieved, normalized, or normalized and stress-relieved.	
May be hot or cold formed. Can be manual welded. For gages under 4″ preheat and elevated interpass temperature are desirable. Stress relief desirable. Peening may be necessary.					May be hot or cold formed. Can be manual welded. Austenitic electrodes are desirable. No preheat required. Stress relief desirable.	May be hot or cold formed. Can be manual welded. For gages over 2″ thick, preheat and elevated interpass temp. are desirable. S.R. desirable.	May be hot or cold formed. May be manual or machine welded. For all gages preheat and elevated interpass temp. are desirable. Stress relief desirable. Peening may be necessary.		May be hot or cold formed. May be manual or machine welded. For gages over ½″ preheat and elevated interpass temp. are desirable. Stress relief desirable. Peening may be necessary.		May be hot or cold formed. May be manual or machine welded. For over .15 carbon preheat and elevated interpass temp. are desirable. S.R. desirable. Peening may be necessary.	
Plate form only. Flange quality to max. gage of 2″ incl. Grades A and B, Fbx. quality to max. gage of 6″ incl. Grades C, D and E, Fbx. quality to max. gage of 4″ incl.					Plate form only. Fbx. quality only to max. gage of 2″ incl.	Plate form only. Fbx. quality only.	Plate form only. Fbx. quality only to max. gage of 2″ incl.		Plate form only. Flg. quality to max. gage of 2″ incl. Grades A and B, Fbx. quality to max. gage of 4″ incl.		Plate form only. Flg. quality to max. gage of 2″ incl. Fbx. quality to max. gage of 4″ incl.	
Boilers, other pressure vessels, low temp. applications or elevated temp. up to 1000° F incl.					Primarily for pressure vessels used in low temperature applications.	Primarily for pressure vessels used in low temperature applications.	Boilers, other pressure vessels for service up to 1000° F inclusive.		Boilers, other pressure vessels for service up to 1000° F inclusive.		Boilers, other pressure vessels for service up to 1000° F inclusive.	

Formability	Weldability	Corrosion Resistance	Available Forms	Uses
Cold forming advised. Power requirements 3 to 4 times carbon steel. Springback greater than carbon steel. For bending use liberal radius.	May be manual or machine welded. Moderate preheat and interpass temp. beneficial for restrained joints and heavy gages.	Atmospheric corrosion resistance approx. 4 times that of carbon steel.	Plates up to 10″ gage inclusive.	Heavily loaded (static or dynamic) structural applications.
			Plates up to 6″ gage inclusive.	Impact abrasion resistance application.
			Plates up to 2″ gage inclusive.	Heavily loaded (static or dynamic) structural applications.
			Plates up to 6″ gage inclusive.	same as above
			Plates ¼″ gage up to 2″ gage inclusive.	ASME Code pressure vessels for temp. from −50°F through 650°F.

This data developed and compiled by Lukens Steel Company, producers of alloy and clad steel plate and heads in the widest range of sizes available anywhere. Depending on gage plates are available in widths up to 195″ and lengths up to 720″.

For copies of this chart, enlarged to 24″x18″, or for further information on the steels described, write to Manager, Marketing Service, 245 Lukens Building, Coatesville, Pennsylvania.

LUKENS

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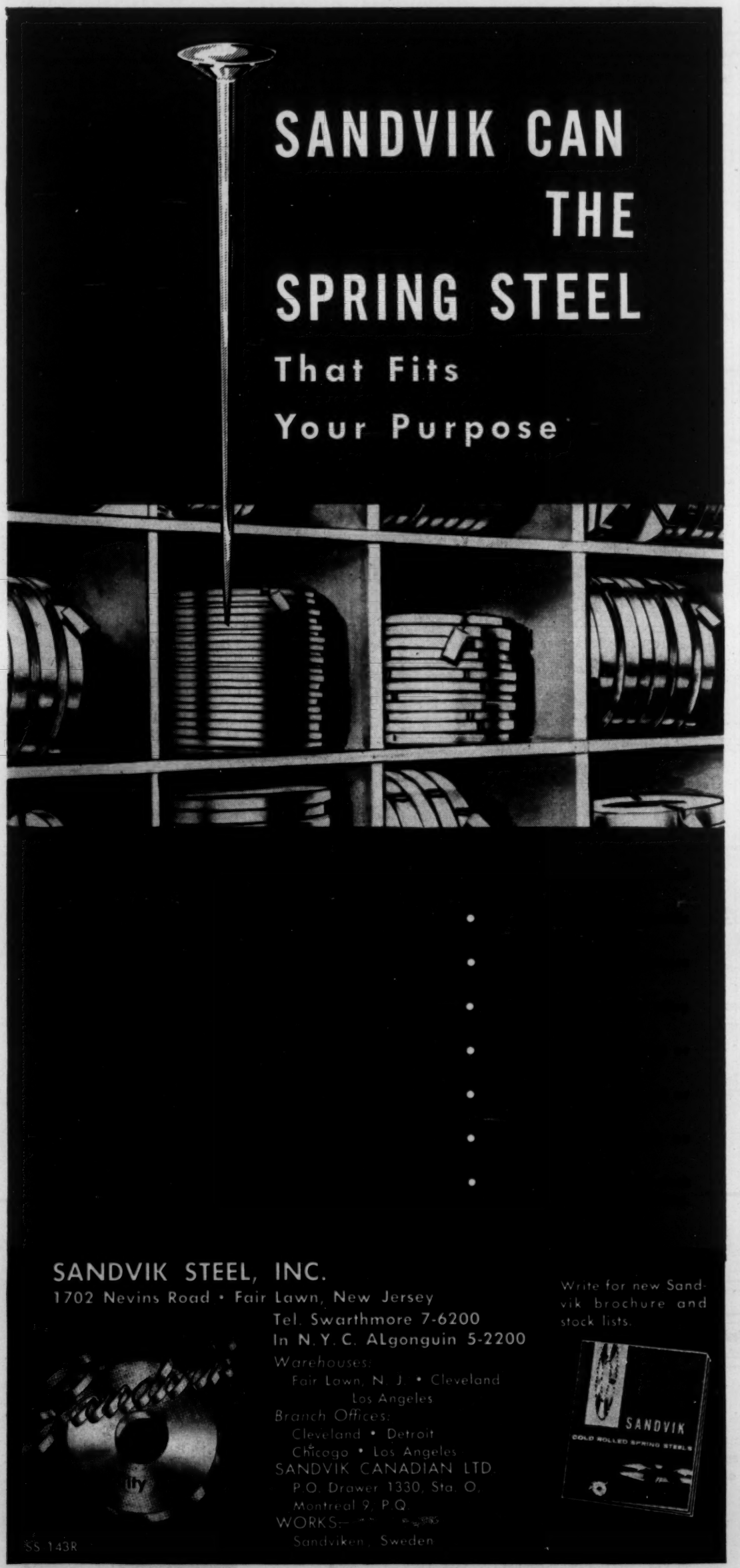

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STAINLESS
GRAY IRON CASTINGS
CARBON AND
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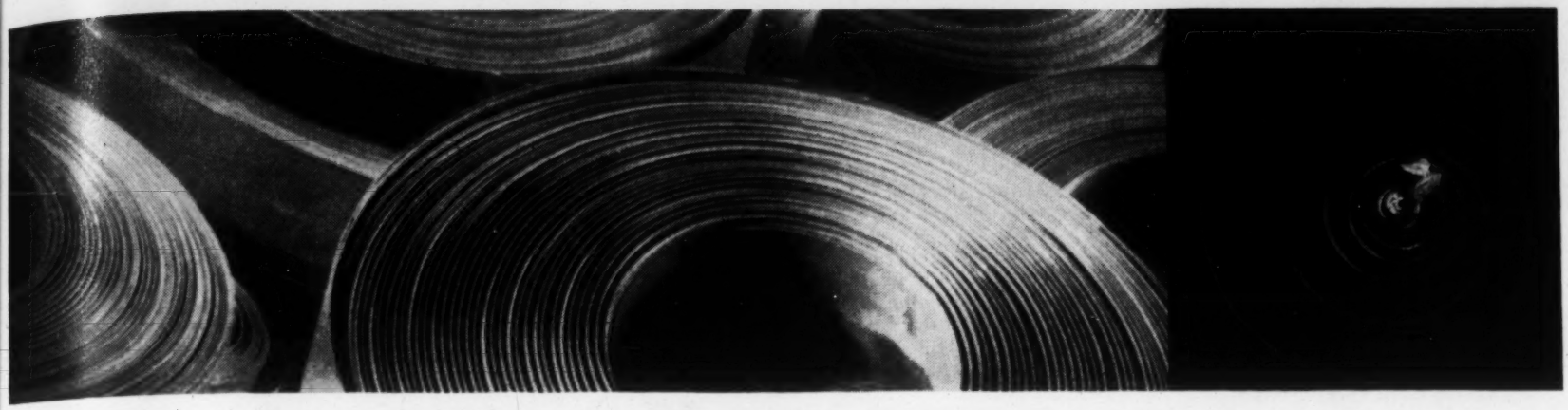
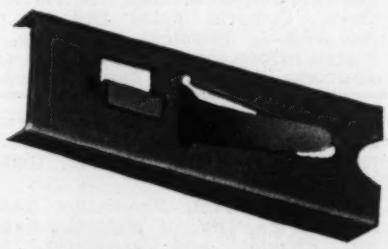


How they're using

Wallace Barnes Cold-rolled Specialty Steels

1. *In Three Drawing Stations*

The part shown in illustration one was made from .59 - .74% carbon steel in three drawing stations. From .70 - .80% carbon, this piece should have four or five drawing stations. The piece could be made from .90 - 1.05% carbon, but would require seven drawing stations with fully annealed steel.



2. *Blanked on 45° Angle*

The stamping shown in the second illustration was made from .70 - .80% carbon spring steel. It was blanked and pierced on a 45° angle, with small holes pierced to prevent fracture in later forming and bending. It was then given severe secondary forming. The small tab shows "orange peel" and probable fracture would occur if the part were formed from .90 - 1.05% carbon.

3. *All Flanging One Operation*

Our third part is a gun stamping made from .70 - .80% carbon with a sharp bend with the grain in one stroke of the press. Higher carbon will fracture due to its less ductile qualities.

4. *Thirteen Steps Progressive*

The fastener shown in the fourth illustration was made from the .59 - .74% carbon steel, the only spring steel which would take the bends and draws to which it is subjected here. All the higher carbon steels were rejected because they failed under the cold-work necessary to produce the two small extrusions. It took seven reductions to bring these extrusions within tolerance. There were thirteen steps total in the progressive die.

These examples show how proper steel selection may save operations and insure satisfactory performance. Among the many sizes and types of Wallace Barnes cold-rolled specialty steels is the right one for your application. Send for "Physical Property Charts" giving tensile strength and forming properties of Wallace Barnes tempered steels.

Wallace Barnes Steel Division

Bristol, Connecticut

Associated Spring Corporation

5808

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Nonferrous Metals

Investment Casting Alloys. Alloy Precision Castings Co., 2 pp, illus. Chemical composition and physical properties of ferrous and nonferrous alloys for investment castings. **59**

Aluminum for Aircraft. Aluminum Co. of America, 16 pp, illus. How weight control of aircraft parts can be achieved through high strength aluminum products. **60**

Copper Products. American Brass Co., 60 pp. Lists sizes, dimensions and availability of copper and brass strip, sheet wire, rod and tube. **61**

Engineering Bronzes. American Crucible Products Co., 12 pp, illus. Technical information, case histories and applications of Promet bronzes. **62**

Bronze Casting Alloys. American Manganese Bronze Co., 50 pp, illus. Gives composition, characteristics and applications of the principal copper alloys used to make castings. **63**

Copper-Base Alloys. American Metal Climax Inc., 6 pp, illus. Properties, uses and fabrication of a number of copper-base alloys with good mechanical and electrical properties. **64**

Prefinished Metals. American Nickeloid Co., 24 pp, illus. Fabrication, uses and properties of prefinished metals. **65**

Bearing Bronze. American Smelting & Refining Co., Continuous-Cast Products Dept., 6 pp, illus., No. 301. Gives stock sizes and weights for solid and hollow continuous-cast bronze bars ½ to 9 in. in dia. **66**

Fusible Alloys. American Smelting & Refining Co., Federated Metals Div., 32 pp, illus. Properties and uses of low melting fusible alloys composed of two or more of the metallic elements, bismuth, lead, tin, cadmium and indium. **67**

Aluminum Bronze Parts. Ampco Metals, Inc., 12 pp, illus., No. PI-5b. Corrosion resistance, strength, and physical and thermal properties of aluminum bronze sand and centrifugal castings, forgings, sheets, plates, rods and tubes. **68**

Beryllium Copper. Beryllium Corp., 48 pp, illus. Physical and mechanical properties and corrosion resistance of beryllium copper alloys supplied in strip, rod, bar and wire. **69**

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Nickel Electrical Alloys. Driver-Harris Co., 94 pp, illus., No. R-56. Information on nickel electrical and resistance alloys and fine gage nickel alloy wire and strip. **78**

Thermometals and Special Alloys. H. A. Wilson Div., Engelhard Industries, Inc., 2655 U.S. Rte. 22, Union, N. J., 192 pp, price $3. Blue Book on thermostatic bimetals, sintered metals, laminated metals and special alloys. Write on company letterhead directly to Wilson.

Tungsten, Molybdenum. Fansteel Metallurgical Corp., Metals & Fabrication Div., 4 pp, illus. Thermal, electrical and mechanical properties of tungsten, tantalum, molybdenum and columbium. **79**

Aluminum Foam. Foamalum Corp., 2 pp, illus. Physical properties, uses and fabrication of aluminum foam. **80**

'Specs' for Aluminum. Peter A. Frasse & Co., Inc., 2 pp. Chemical compositions and specified forms of aluminum alloys for the most frequently used Federal and Military specifications. **81**

Aluminum Alloy. Frontier Bronze Corp., 24 pp, illus. Describes Alloy 40-E, a high strength aluminum alloy that needs no heat treatment. **82**

Electrical Contact Materials. Gibson Electric Co., 16 pp, illus., No. C-520. Properties and uses of electrical contact materials, including fine silver, palladium, nickel, silver alloys and silver cadmium oxides. **83**

Metal Powders. Glidden Co., Chemical-Pigments-Metal Div., 6 pp. Information on lead and Resistox copper powders. **84**

Nonferrous, Ferrous Foil. Hamilton Watch Co., Precision Metals Div., 8 pp, illus. Information on cold rolled ferrous and nonferrous strip and foil available in special alloys and in a range of thicknesses from 0.100 to 0.0001 in. **85**

Indium Alloys. Indium Corp. of America, 93 pp, graphs. Constitution of indium alloy systems. **86**

Designing with Aluminum. Kaiser Aluminum & Chemical Sales, Inc., 54 pp, illus. Techniques for forming, fastening, welding and finishing aluminum. **87**

Laminated Metals. General Findings & Supply Co., and Leach & Garner Co., 8 pp, illus. Sizes and forms of precious and laminated metals for electronic, aircraft and automotive parts. **88**

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Platinum-Clad Metals. Metals & Controls Corp., General Plate Div., 2 pp, illus., No. PLA-5. Physical properties, uses and design information for platinum-clad brass, stainless steel, iron, tantalum and bronze. **94**

Aluminum Bronze. Mueller Brass Co., 7 pp, illus. Chemical and mechanical properties and uses of Tuf-Stuf, high copper-base alloys. **95**

Zirconium Metal. Zirconium Metals Corp. of America, Div. of National Lead Co., 68 pp. Physical and mechanical properties, chemical composition, uses, corrosion and oxidation resistance, machinability and weldability of zirconium metal. **96**

Phosphor Bronze. H. K. Porter Co., Inc., Riverside-Alloy Metal Div., 4 pp, illus., No. T-4. Properties and uses of a fine grain phosphor bronze. **97**

Titanium Alloys. Republic Steel Corp., illus., No. ADV-903. Mechanical properties and typical uses of various titanium alloys. **98**

Corrosion of Aluminum. Reynolds Metals Co., 6 pp, illus. Graphs show yearly corrosion rates of more than 100 chemicals on aluminum. **99**

Brass Strip Sheet. Scovill Mfg. Co., 4 pp, illus. Information on continuous-cast strip and sheet brasses and bronzes. **100**

Copper Alloy. Seymour Mfg. Co., 40 pp, illus. Technical data on nickel silver and phosphor bronze. Includes information on cleaning and annealing. **101**

Electrolytic Chromium, Manganese. Electro Metallurgical Co., Div. of Union Carbide Corp., 4 pp, illus. Properties of electrolytic chromium and manganese. **102**

Nickel and Cobalt Alloys. Haynes Stellite Co., Div. of Union Carbide Corp., 44 pp, illus. Case histories showing the use of cobalt-base cast and wrought alloys and nickel-base cast alloys in bearings, valves, rings, inserts, and bushings. **103**

Molybdenum. Wah Chang Corp., 5 pp. Physical and mechanical properties, fabrication data, uses and corrosion resistance of molybdenum. **104**

Nonferrous Sheet Strip. Waterbury Rolling Mills, Inc., 64 pp, illus. Composition, machinability, grain size and physical properties of nickel silver, phosphor bronze and copper sheet, strip and coils. **105**

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PROPERTIES OF MATERIALS

Nonferrous Metals

	PAGE
Aluminum and Its Alloys	84
Cast Aluminum Alloys	88
Cobalt and Its Alloys	92
Columbium, Tantalum, Tungsten and Molybdenum	93
Coppers and Plain Brasses	94
Cast Leaded Tin Bronzes	96
Cast High-Leaded Tin Bronzes	97
Cast Leaded Red and Semi-Red Brasses	98
Cast Aluminum Bronzes	99
Phosphor Bronzes	100
Nickel Silvers	101
Tin and Aluminum Brasses	102
Hafnium, Thorium, Uranium, Vanadium and Zirconium	103
Lead and Its Alloys (Soft)	104
Lead and Its Alloys (Hard)	105
Magnesium Alloys	106
Cast Magnesium Alloys	107
Magnesium-Thorium and Magnesium-Zirconium Alloys	108
Cast Magnesium-Thorium and Magnesium-Zirconium Alloys	109
Nickel and Its Alloys	110
Cast Nickel Alloys	112
Low Expansion Nickel Alloys	113
Precious Metals	114
Tin and Its Alloys	116
Lead-Tin-Antimony Alloys	117
Titanium and Its Alloys	120
Zinc Alloys	122
Cast Zinc Alloys	123
Advertisements	124
Suppliers' Literature	82

Aluminum and Its Alloys

Type →	1100	3003	3004
COMPOSITION, %	Al 99.0 min	Mn 1.0–1.5	Mn 1.0–1.5, Mg 0.8–1.3
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.098	0.099	0.098
Melting Temp Range, F	1190–1215	1190–1210	1165–1205
Ther Cond (77 F, annealed), Btu/hr/sq ft/°F/ft	128	111	93.8
Coef of Ther Exp (68 to 212 F), per °F	13.1×10^{-6}	12.9×10^{-6}	12.9×10^{-6}
Specific Heat (212 F), Btu/lb/°F	0.22	0.22	0.22
Electrical Resistivity (68 F), microhm-cm			
Annealed	2.92	3.45	4.10
Hard (H18 or H38)[a]	3.02	4.31	4.10
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	10×10^6	10×10^6	10×10^6
Tensile Strength (75 F), 1000 psi			
Annealed (O)	13	16	26
Half Hard	18 (H14)	22 (H14)	35 (H34)
Hard	24 (H18)	29 (H18)	41 (H38)
Yield Strength (75 F), 1000 psi			
Annealed (O)	5	6	10
Half Hard	17 (H14)	21 (H14)	29 (H34)
Hard	22 (H18)	27 (H18)	36 (H38)
Elongation (in 2 in., 75 F), %[a]			
Annealed (O)	35, 45	30, 40	20, 25
Half Hard	9, 20 (H14)	8, 16 (H14)	9, 12 (H34)
Hard	5, 15 (H18)	4, 10 (H18)	5, 6 (H38)
Hardness (Brinell)[b]			
Annealed (O)	23	28	45
Half Hard	32 (H14)	40 (H14)	63 (H34)
Hard	44 (H18)	55 (H18)	77 (H38)
Endurance Limit, 1000 psi			
Annealed (O)	5	7	14
Half Hard	7 (H14)	9 (H14)	15 (H34)
Hard	9 (H18)	10 (H18)	16 (H38)
Shear Strength, 1000 psi			
Annealed (O)	9	11	16
Half Hard	11 (H14)	14 (H14)	18 (H34)
Hard	13 (H18)	16 (H18)	21 (H38)
FABRICATING PROPERTIES			
Annealing Temp, F	650	775	650
Hot Working Temp Range, F	500-950	500-950	500-950
Machinability	Good	Good	Good
Relative Weldability[c]			
Torch	A	A	B
Inert Arc	A	A	A
Electrical Resistance	A	A	A
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions		
AVAILABLE FORMS	Sheet, plate, wire, rod, bar		
	Rivets, forgings, impact extrusions	Extruded shapes, tubing, forgings	Sheet, plate
USES	Cooking utensils, heat exchangers, pressure and storage tanks		Hydraulic tubing for commercial vehicles, storage tanks
	Chemical equipment, reflectors	Ductwork, truck panels, architectural applications, builders' hardware	

[a] Values given for 1/16-in. sheet and 1/2-in. bar, in that order.
[b] 500-kg load, 10-mm ball.
[c] Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.

Aluminum and Its Alloys—continued

Type ➡	5050	5052	5056
COMPOSITION, %	Mg 1.0–1.8	Mg 2.2–2.8, Cr 0.15–0.35	Mn 0.05–0.20, Mg 4.7–5.6, Cr 0.05–0.20
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.097	0.097	0.095
Melting Temp Range, F	1160–1205	1100–1200	1055–1180
Ther Cond (77 F, annealed), Btu/hr/sq ft/°F/ft	111	79.2	67.4
Coef of Ther Exp, per °F			
68 to 212 F	13.2×10^{-6}	13.2×10^{-6}	13.4×10^{-6}
68 to 572 F	14.2×10^{-6}	14.3×10^{-6}	14.5×10^{-6}
Specific Heat (212 F), Btu/lb/°F	0.22	0.22	0.22
Electrical Resistivity (68 F), microhm-cm			
Annealed	—	4.93	5.94
Hard (H18 or H38)[a]	—	4.93	6.39
MECHANICAL PROPERTIES			
Mod of Elasticity in Tension, psi	10×10^6	10.2×10^6	10.3×10^6
Tensile Strength (75 F), 1000 psi			
Annealed (O)	21	28	42
Half Hard	28 (H34)	38 (H34)	—
Hard	32 (H38)	42 (H38)	60 (H38)
Yield Strength (75 F), 1000 psi			
Annealed (O)	8	13	22
Half Hard	24 (H34)	31 (H34)	—
Hard	29 (H38)	37 (H38)	50 (H38)
Elongation (in 2 in., 75 F), %[a]			
Annealed (O)	24	25, 30	—,35
Half Hard	8 (H34)	10, 14 (H34)	—
Hard	6 (H38)	7, 8 (H38)	—,15 (H38)
Hardness (Brinell)[b]			
Annealed (O)	36	47	65
Half Hard	53 (H34)	68 (H34)	—
Hard	63 (H38)	77 (H38)	105 (H18), 100 (H38)
Endurance Limit, 1000 psi			
Annealed (O)	12	16	20
Half Hard	13 (H34)	18 (H34)	—
Hard	14 (H38)	20 (H38)	22 (H38)
Shear Strength, 1000 psi			
Annealed (O)	15	18	26
Half Hard	18 (H34)	21 (H34)	—
Hard	20 (H38)	24 (H38)	32 (H38)
FABRICATING PROPERTIES			
Annealing Temp, F	650	650	650
Hot Working Temp Range, F	—	500–950	500–950
Machinability	Good	Good	Good
Relative Weldability[c]			
Torch	B	B	C
Inert Arc	A	A	A
Electrical Resistance	A	A	B
CORROSION RESISTANCE	High resistance to rural, industrial and marine atmospheres. Good resistance to most neutral or nearly neutral fresh waters; sea water; many foodstuffs; organic acids and anhydrides; alcohols; aldehydes; esters; ketones; oils, gasoline, greases, waxes, and other petroleum derivatives; ammonia and ammonium compounds; nitric acid above 82%; essential oils; amides; nitroparaffins; coal tar derivatives; hydrogen peroxide; and many neutral aqueous inorganic salt solutions		
AVAILABLE FORMS	Sheet, plate, drawn tube	Sheet, plate, wire, rod, bar, drawn tubing	Rod, wire
USES	Decorative refrigerator parts, coiled tubes, builders' hardware	Bus and truck bodies, aircraft tubing, milk crates, fan blades, kitchen cabinets	Cable sheathing, rivets for magnesium

[a]Values given for 1/16-in. sheet and ½-in. bar, in that order. [b]500-kg load, 10-mm ball.
[c]Letter A indicates most favorable, B less favorable, etc. Values relative to aluminum alloys only.

continued

Aluminum and Its Alloys—continued

Type →	2011	2014[a,b]	2017
COMPOSITION, %	Cu 5.0–6.0, Pb 0.2–0.6, Bi 0.2–0.6	Cu 3.9–5.0, Si 0.5–1.2, Mn 0.4–1.2, Mg 0.2–0.8	Cu 3.5–4.5, Mn 0.4–1.0, Mg 0.2–0.8
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.102	0.101	0.101
Melting Temp Range, F	995–1190	950–1180	955–1185
Ther Cond (77 F, annealed), Btu/hr/sq ft/°F/ft	81.7	111.0	99.4
Coef of Ther Exp, per °F			
68 to 212 F	12.8×10^{-6}	12.5×10^{-6}	12.7×10^{-6}
68 to 572 F	13.9×10^{-6}	13.6×10^{-6}	13.9×10^{-6}
Specific Heat, Btu/lb/°F	0.23	0.22	0.22
Electrical Resistivity (68 F), microhm-cm	4.31 (T3)	3.45 (O), 4.31 (T6)	3.83 (O), 5.75 (T4)
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	10.2×10^6	10.6×10^6	10.5×10^6
Tensile Strength, 1000 psi			
Annealed (O)	—	27	26
Heat Treated	55 (T3), 59 (T8)	62 (T4), 70 (T6)	62 (T4)
Yield Strength (0.2% offset), 1000 psi			
Annealed (O)	—	14	10
Heat Treated	43 (T3), 45 (T8)	42 (T4), 60 (T6)	40 (T4)
Elongation (in 2 in.), %			
Annealed (O)	—	18	22
Heat Treated	15 (T3), 12 (T8)	20 (T4), 13 (T6)	22 (T4)
Hardness (Brinell)			
Annealed (O)	—	45	45
Heat Treated	95 (T3), 100 (T8)	105 (T4), 135 (T6)	105 (T4)
Endurance Limit, 1000 psi			
Annealed (O)	—	13	13
Heat Treated	18 (T3), 18 (T8)	20 (T4), 18 (T6)	18 (T4)
Shear Strength, 1000 psi			
Annealed (O)	—	18	18
Heat Treated	32 (T3), 35 (T8)	38 (T4), 42 (T6)	38 (T4)
FABRICATING PROPERTIES			
Annealing Temperature, F	775	775	775
Solution Temperature, F	950	940	940
Aging Temperature, F	320	340	—
Machinability[c]	A (T3,T8)	A (T6)	A (T4)
Relative Weldability[c]			
Torch	D	D	D
Inert Arc	D	B	B
Electrical Resistance	D	B	A
CORROSION RESISTANCE	Compared to other aluminum alloys, this group has high resistance to rural atmospheres, fairly good resistance to industrial atmospheres, and poor resistance to marine atmospheres and sea water. More susceptible to corrosive attack than other groups of wrought aluminum alloys. Both degree and nature of the attack are greatly influenced by thermal treatment. Clad sheet alloys generally have high corrosion resistance		
AVAILABLE FORMS	Rod, hexagon bar, wire	Extruded shapes, rolled shapes, forgings, rod, bar	Rod, bar, wire
USES	Screw machine products	Heavy duty forgings, power shovel bails, airplane fittings, structural members	Screw machine products

[a] 2014 available clad with 6053.
[b] Similar to 2014 is Hardclad 301. Core: 4.0-5.0 Cu, 0.75-1.2 Si, 0.70-1.0 Mn, 0.25-0.55 Mg. Claddings: 0.50-0.90 Si, 0.25-0.75 Mn. 0.80-1.2 Mg.
[c] Letter A indicates most favorable, B less favorable, etc. Relative to aluminum alloys only.

Aluminum and Its Alloys—concluded

Type ➡	2018	2218	2024[d]
COMPOSITION, %	Cu 3.5–4.5, Mg 0.45–0.9, Ni 1.7–2.3	Cu 3.5–4.5, Mg 1.2–1.8, Ni 1.7–2.3	Cu 3.8–4.9, Mn 0.3–0.9, Mg 1.2–1.8
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.101	0.102	0.100
Melting Temp Range, F	945–1180	940–1175	935–1180
Ther Cond (77 F, annealed), Btu/hr/sq ft/°F/ft	89.0	97.0	111.0
Coef of Ther Exp, per °F			
68 to 212 F	12.4 x 10^{-6}	12.4 x 10^{-6}	12.6 x 10^{-6}
68 to 572 F	13.4 x 10^{-6}	13.5 x 10^{-6}	13.7 x 10^{-6}
Specific Heat, Btu/lb/°F	0.22	0.22	0.22
Electrical Resistivity (68 F), microhm-cm	—	—	3.45 (O), 5.75 (T4)
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	10.8 x 10^6	10.8 x 10^6	10.6 x 10^6
Tensile Strength, 1000 psi			
Annealed (O)	—	—	27
Heat Treated	61 (T61)	48 (T72)	70 (T3)
Yield Strength (0.2% offset), 1000 psi			
Annealed (O)	—	—	11
Heat Treated	46 (T61)	37 (T72)	50 (T3)
Elongation (in 2 in.), %			
Annealed (O)	—	—	20[e]
Heat Treated	12 (T61)[f]	11 (T72)[g]	18 (T3)[e]
Hardness (Brinell)			
Annealed (O)	—	—	47
Heat Treated	120 (T61)	95 (T72)	120 (T3)
Endurance Limit, 1000 psi			
Annealed (O)	—	—	13
Heat Treated	17 (T61)	—	20 (T3)
Shear Strength, 1000 psi			
Annealed (O)	—	—	18
Heat Treated	39 (T61)	30 (T72)	41 (T3)
FABRICATING PROPERTIES			
Annealing Temperature, F	775	775	775
Solution Temperature, F	950	950	920
Aging Temperature, F	340	460	375
Machinability[c]	A	A	A (T3)
Relative Weldability[c]			
Torch	D	—	D
Inert Arc	B	—	B
Electrical Resistance	B	—	B
CORROSION RESISTANCE	Compared to other aluminum alloys, this group has high resistance to rural atmospheres, fairly good resistance to industrial atmospheres, and poor resistance to marine atmospheres and sea water. More susceptible to corrosive attack than other groups of wrought aluminum alloys. Both degree and nature of the attack are greatly influenced by thermal treatment. Clad sheet alloys generally have high corrosion resistance		
AVAILABLE FORMS	Forgings	Forgings	Sheet, plate, rod, bar, tubing, wire, rivets, extruded shapes
USES	Aircraft engine cylinder heads and pistons	Aircraft engine cylinder heads and pistons; jet engine impellers and compressor rings	Screw machine products

[c]Letter A indicates most favorable, B less favorable, etc. Relative to aluminum alloys only.
[d]2024 also available as sheet and plate clad with aluminum of 99.3% min purity.
[e]Elongation in 2 in. [f]Elongation in 1½ in. [g]Elongation in ½ in.

Cast Aluminum Alloys[a]

ASTM Type →	C4A	CS42A	CS43A	SC64A
COMPOSITION, %	Cu 4.5, Al bal	Cu 4.5, Si 2.5, Al bal	Cu 4.0, Si 3.0, Al bal	Cu 4.5, Si 5.5, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.101	0.100	0.100	0.100
Solid. Temp Range, F	1195–1020	1160–980	1160–970	1140–960
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	82.5	92.5	70	82
Coef of Ther Exp (68–212 F), per °F	12.7 x 10^{-6}	12.2 x 10^{-6}	12.2 x 10^{-6}	11.9 x 10^{-6}
Elec Cond (as cast), % IACS	36	42.5	31	37
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
As Cast	—	—	19	28
Sol'n Heat Treated	32	37	—	—
Sol'n Treated & Aged	40	40	—	—
Yld Str (0.2% offset), 1000 psi				
As Cast	—	—	14	16
Sol'n Heat Treated	16	22	—	—
Sol'n Treated & Aged	30	26	—	—
Elong (in 2 in.), %				
As Cast	—	—	1.5	2.0
Sol'n Heat Treated	8.5	9.0	—	—
Sol'n Treated & Aged	2.0	5.0	—	—
Hardness (Brinell)				
As Cast	—	—	—	70
Sol'n Heat Treated	60	75	—	—
Sol'n Treated & Aged	95	90	—	—
Endurance Limit, 1000 psi				
Sol'n Heat Treated	6	9.5	—	—
Sol'n Treated & Aged	7	—	—	—
Compr Yld Str, 1000 psi				
As Cast	—	—	—	16
Sol'n Heat Treated	16	22	—	—
Sol'n Treated & Aged	38	26	—	—
Shear Str, 1000 psi				
As Cast	—	—	—	25
Sol'n Heat Treated	24	30	—	—
Sol'n Treated & Aged	31	32	—	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	960	960	960	940
Aging Temp, F	310	310	310	310
FABRICATING PROPERTIES				
Machinability[b]	AB	AB	C	C
Weldability[b]				
Gas	C	C	B	A
Arc	B	B	D	A
Resistance	B	B	B	A
CORROSION RESISTANCE	Good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand castings	Permanent mold castings	Sand castings	Permanent mold castings
USES	Crankcases, bus wheels, housings, spring hangers, fittings	Aircraft fittings, fuel pump bodies, gear housings, seat frames	Manifolds, valve bodies, pressure-tight parts	Parts requiring pressure tightness

[a] General purpose castings. [b] A = excellent, AB = very good, B = good, C = fair, D = poor.

Cast Aluminum Alloys—continued[b]

ASTM Type →	G4A	G10A	S5A	SG70A
COMPOSITION, %	Mg 4.0, Al bal	Mg 4.0, Al bal	Si 5.25, Al bal	Si 7.0, Mg 0.35, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.095	0.093	0.097	0.096
Solid. Temp Range, F	1185–1075	1150–840	1175–1070	1130–1075
Ther Cond (as cast, 68F), Btu/hr/sq ft/°F/ft	80	51	85	92
Coef of Ther Exp (68–212 F), per °F	13.3 x 10^{-6}	13.6 x 10^{-6}	12.2 x 10^{-6}	11.9 x 10^{-6}
Elec Cond (as cast), % IACS	35	21	38	41
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
As Cast	25	—	19	—
Sol'n Heat Treated	—	46	—	—
Aged[g]	—	—	—	25, 40
Yld Str (0.2% offset), 1000 psi				
As Cast	12	—	9	—
Sol'n Heat Treated	—	25	—	—
Aged[g]	—	—	—	20, 27
Elong (in 2 in.), %				
As Cast	9.0	—	6.0	—
Sol'n Heat Treated	—	14	—	—
Aged[g]	—	—	—	2.0, 5.0
Hardness (Brinell)				
As Cast	50	—	40	—
Sol'n Heat Treated	—	75	—	—
Aged[g]	—	—	—	60, 90
Endurance Limit, 1000 psi				
As Cast	5.5	—	6.5	—
Sol'n Heat Treated	—	7	—	—
Compr Yld Str, 1000 psi				
As Cast	12	—	10	—
Sol'n Heat Treated	—	26	—	—
Aged[g]	—	—	—	28, 24
Shear Str, 1000 psi				
As Cast	20	—	14	—
Sol'n Heat Treated	—	33	—	—
THERMAL TREATMENT				
Annealing Temp, F	650	650	650	650
Solution Temp, F	950	960	960	1000
Aging Temp, F	310	310	310	310
FABRICATING PROPERTIES				
Machinability[e]	A	A	C	A
Weldability[e, f]				
Gas	B	D	A, —	A, A
Arc	A	C	A, —	A, A
Resistance	B	B	A, —	A, A
CORROSION RESISTANCE	Very good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Sand castings	Sand castings	Sand and perm mold castings	Sand and perm mold castings
USES	Dairy and food handling equipment, cooking utensils, chemical fittings, hardware	Aircraft fittings, levers, brackets, parts requiring shock resistance	Sand—marine fittings, food handling equipment, pipe fittings. Permanent mold — refrigerator fittings, carburetor bodies, thin-section general purpose castings	Sand—automotive transmission cases, housings, aircraft fittings

[b] Corrosion resistant castings. [e] A = excellent, AB = very good, B = good, C = fair, D = poor.
[f] Where two values are given they refer to sand and permanent mold castings, respectively.
[g] First value obtained by artificial aging; second value by solution treating and aging.

continued

Cast Aluminum Alloys—continued[c]

ASTM Type →	CG100A	CN42A	SC51A
COMPOSITION, %	Cu 10.0, Mg 0.25, Al bal	Cu 4.0, Mg 1.5, Ni 2.0, Al bal	Cu 1.25, Si 5.0, Mg 0.5, Al bal
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.103	0.101	0.097
Solid. Temp Range, F	1160–1005	1165–995	1160–1070
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	77	87	87
Coef of Ther Exp (68–212 F), per °F	12.2×10^{-6}	12.5×10^{-6}	—
Elec Cond (as cast), % IACS	34	38.5	39
MECHANICAL PROPERTIES			
Tensile Strength, 1000 psi			
Artificially Aged	37	40	28
Sol'n Treated & Aged	48	47	43
Yield Strength (0.2% offset), 1000 psi			
Artificially Aged	35	34	23
Sol'n Treated & Aged	36	42	27
Elongation (in 2 in.), %			
Artificially Aged	0.5	1.0	1.5
Sol'n Treated & Aged	0.5	0.5	4.0
Hardness (Brinell)			
Artificially Aged	115	105	65
Sol'n Treated & Aged	140	110	90
Endurance Limit, 1000 psi			
Artificially Aged	8.5	10.5	7
Sol'n Treated & Aged	9	9.5	9
Compressive Yield Strength, 1000 psi			
Artificially Aged	40	34	24
Sol'n Treated & Aged	36	46	27
Shear Strength, 1000 psi			
Artificially Aged	27	26	22
Sol'n Treated & Aged	30	31	30
THERMAL TREATMENT			
Annealing Temp, F	650	650	650
Solution Temp, F	950	960	980
Aging Temp, F	310	310	310
FABRICATING PROPERTIES			
Machinability[e]	AB	AB	B
Weldability[e, f]			
Gas	C, D	C, C	A, A
Arc	B, C	B, B	A, A
Resistance	B, B	B, B	A, A
CORROSION RESISTANCE	Good corrosion resistance; alloy SC51A is superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres		
AVAILABLE FORMS	Sand and permanent mold castings	Sand and permanent mold castings	Sand and permanent mold castings
USES	Sand—cylinder heads, bearing caps, bushings, tappet guides. Permanent mold—Meter parts, automotive pistons, bushings, bearings	Sand—cylinder heads, diesel engine pistons	Sand—cylinder heads, water jackets, housings, printing press bed plates. Permanent mold—aircraft supercharger impellers, timing gears, meter parts, rotors

[c] High temperature resistant castings.
[e] A = excellent, AB = very good, B = good, C = fair, D = poor.
[f] The two values refer to sand and permanent mold castings, respectively.

Cast Aluminum Alloys—concluded[d]

ASTM Type ➡	G8A	S5C	S12A	SC84A
COMPOSITION, %	Mg 8.0, Al bal	Si 5.25, Al bal	Si 12.0, Fe 1.3 max, Al bal	Cu 3.5, Si 8.5, Fe 1.3 max, Al bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.093	0.097	0.097	0.097
Solid. Temp Range, F	1150–995	1175–1070	1085–1065	1100–1000
Ther Cond (as cast, 68 F), Btu/hr/sq ft/°F/ft	56	84	70	58
Coef of Ther Exp (68–212 F), per °F	13.3×10^{-6}	12.2×10^{-6}	11.4×10^{-6}	11.7×10^{-6}
Elec Cond (as cast), % IACS	24	38	31	25
MECHANICAL PROPERTIES				
Ten Str, 1000 psi	45	30	39	46
Yld Str (0.2% offset), 1000 psi	27	16	21	25
Elong (in 2 in.), %	8.0	9.0	2.0	3.0
Endurance Limit, 1000 psi	23	17	19	19
Compr Yld Str, 1000 psi	27	16	21	25
Shear Str, 1000 psi	27	19	25	29
FABRICATING PROPERTIES				
Machinability[e]	A	C	A	AB
Weldability[e]				
Gas	D	B	D	D
Arc	D	B	D	D
Resistance	D	C	D	D
CORROSION RESISTANCE	Good corrosion resistance; alloys containing silicon are superior. In general: Resistant to nitric, chromic and most organic acids; attacked by hydrochloric and sulfuric acids. Resistant to ammonium hydroxide; attacked by sodium, potassium and calcium hydroxides. Resistant to many salts, but attacked by salts of heavy metals. Resistant to attack by industrial and marine atmospheres			
AVAILABLE FORMS	Die castings	Die castings	Die castings	Die castings
USES	Aircraft fittings and brake shoes, marine fittings, hardware	General purpose castings	Dental equipment, outboard motor pistons, typewriter frames	General purpose castings

[d] Die castings.
[e] A = excellent, AB = very good, B = good, C = fair, D = poor.

Cobalt and Its Alloys

Type →	Cobalt		AMS 5385C	AMS 5537
COMPOSITION, %	Co 99.9	C 0.06–0.3, Co 98	C 0.20–0.35, Mn 1.0 max, Ni 1.5–3.5, Mo 4.5–6.5, Cr 25–30, Fe 2.0 max, Si 1.0 max, B 0.07 max	C 0.05–0.15, Mn 1.0–2.0, Ni 9–11, Cr 19–21, Fe 3.0 max, W 14–16, Si 1.0 max, Co 46–53
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.322	—	0.299	0.333
Melting Point, F	2723	—	2465	2570
Ther Cond, Btu/hr/sq ft/°F/ft	479	—	101 (392 F)	—
Coef of Ther Exp, per °F	6.8×10^{-6}	—	7.8×10^{-6}	—
Magnetic?	Yes	Yes	Yes	Yes
Curie Temperature, F	2039	—	—	—
Thermal Neutron Absorption, barns/atom	34.8	—	—	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	30×10^6	—	16.8×10^6 [a]	35×10^6
Tensile Strength, 1000 psi				
Annealed	37	43–75	—	145–165
Sintered	98.5	—	—	—
Cold Worked	100	—	—	—
As Cast	34.4	61	103	—
Aged 50 hr at 1300 F	—	—	125	—
Yield Strength, 1000 psi				
Annealed	28–41	20–65	—	65–85
Sintered	43.8	—	—	—
As Cast	20–43	33	82	—
Aged 50 Hr at 1300 F	—	—	110	—
Elongation (in 2 in.), %				
Annealed	0–8	13	—	70–55
Sintered (1 in.)	13.5	—	—	—
Cold Worked	2–8	—	—	—
As Cast	0–4	5–30	8	—
Aged 50 Hr at 1300 F	—	—	2	—
Hardness (Brinell)				
Annealed	121–131 [d]	138	—	225
Sintered (VHN)	173	—	—	—
As Cast	124–130	100–131	R_A65	—
Aged 50 Hr at 1300 F	—	—	R_A71	—
Compressive Strength, 1000 psi				
Annealed	117	140	—	—
As Cast	122	175	—	—
Mod of Elast in Shear, psi	11.1×10^6	—	—	—
Impact Strength, ft-lb				
Room Temp	—	—	2.9 [b]	120 [c]
1500 F	—	—	11 [b]	—
THERMAL TREATMENT				
Annealing Temp, F	—	—	2175–2200	2225
Solution Temp, F	—	—	—	2200
Hardening Temp, F	—	—	1475–1500	—
FABRICATING PROPERTIES				
Hot Working Temp Range, F	930–1100	—	—	—
Machinability	Possible	Possible	Poor	Good
Weldability	—	—	Shield arc	Good
CORROSION RESISTANCE	Excellent	Excellent	Resistant to oxidizing media, flue gases	Highly resistant to scaling and oxidation at elevated temperatures
AVAILABLE FORMS	Rondelles, powders	Rondelles, powders	Precision castings, sand castings, bar, sheet, welding rod	Sheet, plate, bar, tubing, wire

[a] At 1500 F as cast.
[b] Charpy V-notch.
[c] Izod impact strength on notched or unnotched specimen; actually specimen stops pendulum.
[d] Hardness of electrolytic cobalt is 270-310 Bhn.

Columbium, Tantalum, Tungsten and Molybdenum

Metal ➡	Columbium	Tantalum	Tungsten	Molybdenum
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.31	0.60	0.70	0.37
Melting Point, F	4379	5425	6152	4760
Ther Cond (212 F), Btu/hr/sq ft/ °F/ft	31.5	31.5	96.6	84.5
Coef of Ther Exp (70 F), per °F	3.82 x 10^{-6} [a]	3.6 x 10^{-6}	2.2 x 10^{-6}	3.0 x 10^{-6}
Specific Heat, Btu/lb/°F	0.065	0.036	0.034	0.065
Elec Res (68 F), microhm-cm	14.2	12.4	5.48[b]	5.17[b]
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	—	27 x 10^6	50 x 10^6	42 x 10^6
Ten Str, 1000 psi				
Annealed	50	50–100	—	85–130[c], 88[d]
Cold Worked	100	110–180	70–300	120–175[c]
Yld Str, 1000 psi				
Annealed	—	—	—	—
Cold Worked	—	—	—	—
Elong (in 2 in.), %				
Annealed	30	11–40	—	4–7[c], 42[d]
Cold Worked	5	1–1.5	0	1[c]
Hardness (Rockwell)				
Annealed	E80	E60	—	B95[c]
Cold Worked	E100	E95	C37–C47	C22–27[c]
FABRICATING PROPERTIES				
Workability	Easily cold worked	Easily cold worked	Must be hot worked except fine wire	Thin sheet and wire can be cold worked, heavier material hot worked
Annealing Temp, F	1950 in vacuum	1950 in vacuum	1830 in protective atm	Anneal to specified mechanical properties
Machinability	Like cold rolled steel, with proper lubricants	Like cold rolled steel, with proper lubricants	Difficult, even with special tools and methods; grinding recommended	Like cast iron, but tool life is shorter
Joining	Weldable to itself and other metals by resistance or inert arc welding. Special methods necessary	Weldable to itself and other metals by resistance or inert arc welding. Special methods necessary	Weldable to itself by inert arc with special methods; to other metals by brazing or resistance welding	Thin sheet can be resistance welded, heavier sections inert arc welded with special methods. Can be brazed to other metals
CORROSION RESISTANCE	Resistant to most acids (except hydrofluoric); resistant to most liquid metals. Less resistant to alkalis	More resistant than columbium to acids (except hydrofluoric); resistant to most liquid metals, metallic salts and compounds. Less resistant to alkalis	Resists most acids and alkalis to 212 F, attacked by nitric-hydrofluoric mixture at room temperature, by aqua regia at 212 F	Moderately resistant to acids and alkalis up to 212 F, attacked by nitrichydrofluoric mixture at room temperature, by aqua regia at 212 F
AVAILABLE FORMS	Bar, rod, wire, sheet, foil, tubing, powder, fabricated parts	Bar, rod, wire, sheet, foil, tubing, powder, fabricated parts	Bar, rod, wire, sheet, powder, fabricated parts	Bar, rod, wire, sheet, tubing, powder, fabricated parts
USES	Nuclear reactors, missles, rockets, chemical plant equipment, electronic tubes	Capacitors, chemical plant equipment, electronic tubes, rectifiers, surgical implants, nuclear reactors, missiles, rockets, aircraft	Lamp filaments, electrical contacts, nuclear reactors, rockets, missiles, aircraft, radiation shields, electronic tube parts, x-ray targets	Glass melting electrodes, electronic tube parts, furnace heating elements, electrical contacts, aircraft, missile and rocket structural parts, guidance systems

[a] 32–1832 F [b] 32 F [c] From powder. [d] Arc melted.

Coppers and Plain Brasses

Type →	Electrolytic Tough Pitch Copper	Deoxidized Copper	Beryllium Copper	Gilding, 95%	Commercial Bronze, 90%
COMPOSITION, %	Cu 99.90 min, O about 0.04	Cu 99.90 min, P 0.015–0.040	Be 1.90–2.15, Co 0.20–0.35, Cu bal	Cu 94.0–96.0, Zn bal	Cu 89.0–91.0, Zn bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.321–0.323	0.323	0.296–0.298	0.320	0.318
Melting Temp Range, F	1949–1981	1981	1600–1800	1920–1950	1870–1910
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	226	196	100–110[a]	135	109
Coef of Ther Exp (68–572 F), per °F	9.8×10^{-6}	9.8×10^{-6}	9.3×10^{-6}	10.0×10^{-6}	10.2×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.092	0.092	0.10[b]	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	1.71	2.03	4.82–5.82[a]	3.1	3.9
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17×10^6	17×10^6	19×10^6	17×10^6	17×10^6
Ten Str, 1000 psi[c]					
Annealed	32, 35	32	60–80, 60–80[e]	34	37, 40
Hard	50, 55	50	165–185, 165–185[f]	56	54, 74
Yld Str, 1000 psi[c,d]					
Annealed	10	10	25–35, 20–30[e]	10	10
Hard	45	45	130–150, 150–170[f]	50	54
Elong (in 2 in.), %[c]					
Annealed	45, 35	45	35–50, 35–50[e]	45	45, 50
Hard	6, 1.5	8	3–12, 2–5[f]	5	5, 4
Hardness (Rockwell)					
Annealed	F40	F40	B50–65[e]	F46	F53
Hard	B50	B50	C36–41[f]	B64	B70
Shear Str, 1000 psi[c]					
Annealed	22, 24	22	50–60[e]	26	28, 30
Hard	28, 29	28	90–100[f]	37	38, 42
Endurance Limit (10^8 cycles), 1000 psi[c]					
Annealed	11	—	30–35, 12–20[e,g]	—	10
Hard	13	19	35–40, 120–140[f,g]	—	17, 21
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Good	Excellent	Excellent
Hot Workability	Excellent	Excellent	Excellent	Good	Good
Hot Working Temp, F	1400–1600	1400–1600	1050–1475	1400–1600	1400–1600
Annealing Temp, F	700–1200	700–1200	1400–1475	800–1450	800–1450
Machinability Index[h]	20	20	20	20	20
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Excellent	Good	Excellent	Excellent
Oxyacetylene Welding	Poor	Fair	Poor	Fair	Good
Carbon Arc Welding	Fair	Good	Excellent	Good	Good
Resistance Welding	Poor	Poor	Excellent	Poor	Poor
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides. Good resistance to weak acids and bases; some resistance to strong acids and bases				
AVAILABLE FORMS	Flat products, rod, wire, tube, pipe, shapes	Tube, pipe, rod, rolled strip	Flat products, rod, wire, tube, pipe, shapes	Rolled strip	Rolled strip, sheet, wire, tube, plate, rod
USES	Architectural trim; automobile radiators; electrical contacts, conductors and switches; ball floats; rivets; chemical process equipment	Plumbing and gas lines; heat exchanger tubes; air, water, gasoline and oil lines; rotating bands	Instrument and valve springs, plunger guides, bushings, bearings, cams, diaphragms, bellows, electrical contacts, resistance welding electrodes	Coins, bullet jackets, fuse caps, primers, jewelry, base for gold plate or vitreous enamel	Grillwork, cosmetic compacts, marine hardware, primer caps, costume jewelry, vitreous enamel base

[a] Heat treated. [b] 86-212 F. [c] Where two values or ranges appear, second is for wire.
[d] 0.5% extension under load except beryllium copper (0.2% offset). [e] Solution annealed.
[f] Annealed and heat treated 2-3 hr at 600 F. [g] Proportional limit. [h] Based on free-cutting brass = 100.

Coppers and Plain Brasses—concluded

Type ➡	Red Brass, 85%	Low Brass, 80%	Cartridge Brass, 70%	Yellow Brass	Muntz Metal
COMPOSITION, %	Cu 84.0–86.0, Zn bal	Cu 78.5–81.5, Zn bal	Cu 68.5–71.5, Zn bal	Cu 63.0–68.5, Zn bal	Cu 59.0–63.0, Zn bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.316	0.313	0.308	0.306	0.303
Melting Temp Range, F	1810–1880	1770–1830	1680–1750	1660–1710	1650–1660
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	92	81	70	67	71
Coef of Ther Exp (68–572 F), per °F	10 4 x 10^{-6}	10.6 x 10^{-6}	11.1 x 10^{-6}	11.3 x 10^{-6}	11.6 x 10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	4.7	5.4	6.2	6.4	6.2
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	17 x 10^6	16 x 10^6	16 x 10^6	15 x 10^6	15 x 10^6
Ten Str, 1000 psi[c]					
Annealed	39, 41	42, 44	44, 48	46, 50	54
Hard	70, 88	74, 107	76	74, 110	—
Yld Str, 1000 psi[c,d]					
Annealed	10	12	11	14	21
Hard	57	59	63	60	—
Elong (in 2 in.), %[c]					
Annealed	48, 48	52, 55	66, 64	65, 60	45
Hard	5, 6	7, 5	8	8, 8	—
Hardness (Rockwell)					
Annealed	F56	F57	F54	F58	F80
Hard	B77	B82	B82	B80	—
Shear Str, 1000 psi[c]					
Annealed	31, 31	32, 32	32, 34	32, 34	40
Hard	42, 48	43, 53	44	43, 55	—
Endur Limit (10^8 cycles), 1000 psi[c]					
Annealed	10.5	14	10	13.5	—
Hard	21, 29	22, 23	21	19, 20	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Excellent	Excellent	Excellent	Fair
Hot Workability	Good	Fair	Fair	Poor	Excellent
Hot Working Temp, F	1450–1650	1500–1650	1350–1550	—	1150–1450
Annealing Temp, F	800–1350	800–1300	800–1400	800–1300	800–1100
Machinability Index[j]	30	30	30	30	40
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Excellent	Good	Good	Good	Good
Oxyacetylene Welding	Good	Good	Good	Good	Good
Resistance Welding	Poor	Poor	Fair	Fair	Fair
CORROSION RESISTANCE	Generally good resistance to industrial, rural and marine atmospheres; also gasolines, fuel oils and lacquers. Generally poor resistance to ammonia, ferric and ammonium compounds, and cyanides				
	Good res to weak acids and bases; some res to strong acids and bases. Highly res to dezincification or stress-corrosion cracking	Susceptible to dezincification and stress corrosion cracking			
		Good res to weak bases; some res to strong bases and weak acids; poor res to strong acids	Some resistance to weak acids and bases; poor resistance to strong acids and bases. Good resistance to sulfides. Poor resistance to soft and high salinity water		
AVAILABLE FORMS	Rolled strip, sheet, wire, tube, pipe	Wire, rolled strip and flat wire	Rolled strip and bar, flat wire, sheet, rod, wire, tube	Rolled strip and flat wire, drawn flat wire, sheet, plate, rod, wire	Rolled strip and bar, sheet, plate, rod, tube
USES	Weatherstrip, electrical sockets, fasteners, heat exchanger tubes, flexible hose, plumbing, jewelry	Ornamental metal work, battery caps, musical instruments, clock dials, pump lines	Automotive radiator cores and tanks, lamp fixtures, fasteners, springs, ammunition components	Grillwork, reflectors, lamp fixtures, fasteners, stencils, plumbing accessories, springs	Architectural trim, large nuts and bolts, condenser plates, hot forgings, valve stems

[c]Where two values appear, second is for wire. [d]0.5% extension under load. [j]Based on free-cutting brass = 100.

Cast Leaded Tin Bronzes

BBII Grade ➡	2A	2B	2C
COMPOSITION, %	Cu 88, Sn 6, Pb 1.5, Zn 4.5	Cu 87, Sn 8, Pb 1, Zn 4	Cu 87, Sn 8, Pb 1, Zn 2
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.311-0.318	0.314-0.320	0.314-0.320
Melting Temp Range, F	1830	1830-1570	1830-1570
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	28	28
Coef of Ther Exp (70-350 F), per °F	10.3×10^{-6}	10×10^{-6}	10×10^{-6}
Electrical Conductivity (68 F), % IACS	14	11	11
MECHANICAL PROPERTIES[a]			
Mod of Elast in Tension, psi	$12\text{-}16 \times 10^6$	$10.6\text{-}16 \times 10^6$	$10.6\text{-}16 \times 10^6$
Tensile Strength, 1000 psi	36-48	33-43	36-46
Yield Strength (0.5% ext), 1000 psi	16-21	16-24	18-26
Elongation (in 2 in.), %	25-40	18-30	15-25
Reduction of Area, %	16-33	15-30	12-26
Hardness (Brinell)	60-72	60-75	65-80
Impact Strength (Izod), ft-lb	11-16	12-15	7-10
Compressive Yield Strength (0.001-in. set), 1000 psi	12-15	9-11	12-14
FABRICATING PROPERTIES			
Casting Temp Range, F			
Light Castings	2000-2300	2100-2300	1200-2300
Heavy Castings	1900-2150	1920-2100	1920-2100
CORROSION RESISTANCE	Generally the same as nonleaded alloys of similar composition		
USES	Oil pumps, gears, bushings, high duty bearings, ornamental bronze	General utility structural bronze, pipe fittings, expansion joints, pressure valves and fittings	Bolts, nuts, gears, valves, pump pistons, pressure pipe fittings, expansion joints

[a]Values are given for the as-cast condition.

Cast High-Leaded Tin Bronzes

BBII Grade →	3A	3B	3D	3E
COMPOSITION, %	Cu 80, Sn 10, Pb 10	Cu 83, Sn 7, Pb 7, Zn 3	Cu 78, Sn 7, Pb 15	Cu 71, Sn 5, Pb 24
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.321-0.328	0.320-0.322	0.329-0.340	0.332-0.343
Melting Temp (approx), F	1770	1800	1750	1700
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	27	—	—	—
Coef of Ther Exp (70-400 F), per °F	10.2×10^{-6}	10×10^{-6}	10.3×10^{-6}	—
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension	$8.5\text{-}13 \times 10^{6}$	—	$8.8\text{-}12.6 \times 10^{6}$	$9\text{-}12 \times 10^{6}$
Ten Str, 1000 psi	27-37	30-38	25-33	23-30
Yld Str (0.5% ext), 1000 psi	15-22	17-21	14-20	11-15
Elongation (in 2 in.), %	8-12	12-20	10-18	7-16
Red. of Area, %	5-11	10-22	8-15	5-12
Hardness (Brinell)	55-70	55-65	50-60	42-35
Impact Str (Izod), ft-lb	2-8	—	4-6	4-6
Compr Yld Str (0.001-in. set), 1000 psi	12.5-16	—	13-16	12-14
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2000-2250	2000-2250	2000-2250	2000-2200
Heavy Castings	1850-2100	1900-2050	1900-2100	1850-2000
CORROSION RESISTANCE	Generally the same as for nonleaded alloys of similar composition			
USES	General purpose bushing and bearing alloy	General purpose bearing alloy, bushings, automobile fittings	Bearing bronze for moderate pressure, mine water pump parts	Bearings operating at high speed and light or medium pressure

[a]Values are given for the as-cast condition.

Cast Leaded Red and Semi-Red Brasses

BB11 Grade ➡	Leaded Red Brass		Leaded Semi-Red Brass	
	4A	4B	5A	5B
NOMINAL COMPOSITION, %	Cu 85, Sn 5, Pb 5, Zn 5	Cu 83, Sn 4, Pb 6, Zn 7	Cu 81, Sn 3, Pb 7, Zn 9	Cu 76, Sn 3, Pb 6 Zn 15
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.314–0.321	0.311–0.314	0.311–0.318	0.309–0.314
Melting Temp Range, F	1840–1550	1800	1800	1775
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	36	—	—	—
Coef of Ther Exp (70–400 F), per °F	10.9×10^{-6}	—	—	—
Elec Cond (68 F), % IACS	15	—	18	—
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	$9.1–14.8 \times 10^6$	—	$7.7–14.3 \times 10^6$	$10–14 \times 10^6$
Ten Str, 1000 psi	33–46	30–38	29–39	30–40
Yld Str (0.5% ext), 1000 psi	17–24	12–17	13–17	12–16
Elongation (in 2 in.), %	20–35	15–27	18–30	20–35
Red. of Area, %	17–32	12–25	15–27	15–30
Hardness (Brinell)	55–65	50–60	50–60	50–60
Impact Str (Izod), ft-lb	6–12	—	6–10	—
Compr Yld Str (0.001-in. set), 1000 psi	10–12	11–12	—	8–10
FABRICATING PROPERTIES				
Casting Temp Range, F				
Light Castings	2100–2350	2100–2300	2100–2300	2100–2300
Heavy Castings	1950–2150	1950–2150	1950–2150	1950–2150
CORROSION RESISTANCE	Generally the same as for nonleaded alloys of similar composition			
USES	Low pressure valve bodies, pipe fittings, pump impellers, plumbing goods, small gears	Air, gas and water fittings, valves, pump parts, hardware, carburetors, injectors	Low pressure valves and fittings, hardware, plumbing fittings, ornamental castings	Plumbing fixtures, air and gas fittings, hardware, low pressure valves and fittings

[a] Values are given for the as-cast condition.

Cast Aluminum Bronzes

BBII Grade ➡	9A	9B	9C	9D
COMPOSITION, %	Cu 87.5, Al 9, Fe 3.5	Cu 89, Al 10, Fe 1	Cu 83 min, Al 10–11.5, Fe 3–5, Ni 2.5 max, Mn 0.5 max	Cu 81, Al 11, Fe 4, Ni 4
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.267	0.270	0.272	0.273
Melting Point Range, F	—	1900	1910–1850	1937
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	33	—	22
Coef of Ther Exp, per °F	9.5 x 10^{-6} [a]	9.5 x 10^{-6} [b]	9.0 x 10^{-6} [b]	—
Elec Res (68 F), microhm-cm	13	13.5	12	7.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	17 x 10^6	15 x 10^6	18 x 10^6	17 x 10^6
Ten Str, 1000 psi				
Sand Cast	75	67	75	95
Sand Cast & Heat Treated	—	90 [c]	105 [d]	115 [e]
Yld Str (0.5% ext), 1000 psi				
Sand Cast	27	32	35	45
Sand Cast & Heat Treated	—	40 [c]	52 [d]	70 [e]
Elongation (in 2 in.), %				
Sand Cast	35	15	18	7
Sand Cast & Heat Treated	—	15 [c]	10 [d]	5 [e]
Hardness (Brinell)				
Sand Cast	120	140	155	195
Sand Cast & Heat Treated	—	180 [c]	230 [d]	235 [e]
THERMAL TREATMENT				
Normalizing Temp, F	Heat to 1500, furnace cool to 1000, air cool			
Quenching Temp, F	1600–1700	1600–1700	1600–1700	1600–1700
Tempering Temp, F	700–1200	700–1200	700–1200	700–1200
FABRICATING PROPERTIES				
Castability	Because of narrow freezing ranges and high shrinkage, aluminum bronzes are difficult to cast. In addition, they are sensitive to gases. In melting, precautions must be taken to minimize stirring and breaking the oxide skin on the surface of the melt to prevent absorption of gases. In pouring, agitation must be avoided, and castings are generally bottom gated to reduce turbulence. Shrinkage difficulties are overcome by use of large risers (to feed the casting) and chills			
Machinability Index (free-cutting brass = 100)	20–30	20–30	20–30	20–30
Weldability	Can be welded by carbon arc, inert-gas arc and resistance methods. Can be brazed with silver brazing alloys, but require special fluxes			
CORROSION RESISTANCE	Generally good resistance to atmosphere, water and salt water, and salt solutions. Some resistance to alkaline solutions and nonoxidizing inorganic acids. Poor resistance to ammonia compounds, ferric salts and oxidizing inorganic acids			
USES	Machine parts, pump impellers and castings, gears, rolling mill bearings, segments and washers, bearings, chemical plant equipment, pickling equipment such as chains and hooks, marine propellers, pump casings, fittings			

[a] 70-250 F. [b] 70-500F.
[c] Water quenched from 1625 F, tempered at 1125 F, water quenched.
[d] Water quenched from 1625 F, tempered at 1000 F, water quenched.
[e] Water quenched from 1625 F, tempered at 1150 F, water quenched.

Phosphor Bronzes

Type →	Phosphor Bronze, 5% (Grade A)	Phosphor Bronze, 8% (Grade C)	Phosphor Bronze, 10% (Grade D)	Phosphor Bronze, 1.25% (Grade E)
COMPOSITION, %	Cu 94.0 min, Sn 3.5–5.8, P 0.03–0.35	Cu 90.5 min, Sn 7.0–9.0, P 0.03–0.35	Cu 88.5 min, Sn 9.0–11.0, P 0.03–0.25	Cu 98.5 min, Sn 1.0–1.5, P trace
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.320	0.318	0.317	0.321
Melting Temp Range, F	1750–1920	1620–1880	1550–1830	1900–1970
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	47	36	29	120
Coef of Ther Exp (68–572 F), per °F	9.9×10^{-6}	10.1×10^{-6}	10.2×10^{-6}	9.9×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	9.6	13	16	3.6
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	16×10^6	16×10^6	16×10^6	17×10^6
Ten Str, 1000 psi[a]				
Annealed	47, 50	55, 60	66, 66	40, —
Half Hard	68, 85	76, 105	83, 118	55, —
Hard	81, 110	93, 130	100, 147	65, 76
Spring	100, 140	112, —	122, —	75, —
Extra Spring	107, —	120, —	128, —	—, —
Yld Str, 1000 psi[b]				
Annealed	19	24	28	14
Half Hard	55	55	—	—
Hard	75	72	—	50
Elong (in 2 in.), %				
Annealed	64	70	68	48
Half Hard	28	32	32	16
Hard	10	10	13	8
Spring	4	3	4	4
Extra Spring	3	2	3	—
Hardness (Rockwell)				
Annealed	B26	B50	B55	—
Half Hard	B78	B84	B92	B64
Hard	B87	B93	B97	B75
Spring	B95	B98	B101	B79
Extra Spring	B97	B100	B103	—
FABRICATING PROPERTIES				
Cold Workability	Excellent	Good	Good	Excellent
Hot Workability	Poor	Poor	Poor	Good (1450–1600 F)
Annealing Temp, F	900–1250	900–1250	900–1250	900–1200
Machinability Index[c]	20	20	20	20
Joining				
Soft Soldering	Excellent	Excellent	Excellent	Excellent
Silver Alloy Brazing	Good	Good	Good	Excellent
Oxyacetylene Welding	Good	Good	Good	Good
Resistance Welding	Good	Excellent	Excellent	Fair
Common Processes	Blanking, drawing, forming and bending, heading and upsetting, roll threading and knurling, shearing, stamping	Blanking, drawing, forming and bending, shearing, stamping	Blanking, forming and bending, shearing	Blanking, forming and bending, heading and upsetting, shearing, squeezing and swaging
CORROSION RESISTANCE	Generally good resistance to atmosphere, water and salt water, and salt solutions. Some resistance to alkaline solutions and inorganic acids. Poor resistance to organic acids, cyanides, and ferric and ammonium compounds			
AVAILABLE FORMS	Rolled strip, rolled flat wire, rod, wire, tube	Rolled strip, rod, wire		Rolled strip, wire
USES	Bridge bearing plates, chemical hardware, perforated sheets, textile machinery, welding rods, beater bars, bellows, clutch disks, cotter pins, diaphragms, fuse clips, fasteners, lock washers, sleeve bushings, springs, switch parts, truss wire, wire brushes		Heavy bars and plates for severe compression, good wear and corrosion resistance. Bridge and expansion plates	Electrical contacts, flexible hose, pole-line hardware

[a]Two values are for flat products and wire, respectively. [b]0.5% extension under load. [c]Based on free-cutting brass = 100.

Nickel Silvers

Type →	65-18	65-12	65-12 Leaded	65-10	55-18
COMPOSITION, %	Cu 65, Ni 18, Zn 17	Cu 65, Ni 12, Zn 23	Cu 65, Ni 12, Zn 21, Pb 2	Cu 65, Ni 10, Zn 25	Cu 55, Ni 18, Zn 27
PHYSICAL PROPERTIES					
Density (68 F), lb/cu in.	0.316	0.314	0.314	0.313	0.314
Melting Temp Range, F	1960–2030	1830–1900	1830–1900	1800–1870	1830–1930
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	19	23	22	26	17
Coef of Ther Exp (68–572 F), per °F	9.0×10^{-6}	9.0×10^{-6}	9.0×10^{-6}	9.1×10^{-6}	9.3×10^{-6}
Spec Ht/(68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Cond (68 F), % IACS	6	8	7.5	9	5.5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	18×10^6	18×10^6	17×10^6	17.5×10^6	18×10^6
Ten Str, 1000 psi					
Annealed	56–60	52–61	52–55	49–63	60
Half Hard	70–86	73	—	73–85	—
Hard	85–103	85	70–89	86–105	100
Extra Hard	—	93	—	95	108
Yld Str, 1000 psi[a]					
Annealed	25–30	18–28	18–24	18–28	27
Half Hard	60–80	60	—	60	—
Hard	74–90	75	60–79	75	85
Extra Hard	—	79	—	76	90
Elong (in 2 in.), %					
Annealed	56–60	35–48	40	35–50	40
Half Hard	7–20	11	—	7–12	—
Hard	3	4	3–18	4–5	3
Extra Hard	—	2	—	3	2.5
Hardness (Rockwell)					
Annealed	B40–55	B22–55	B27	B22–52	B55
Half Hard	B78–83	B80	—	B80	—
Hard	B87	B89	B80–86	B89	B91
Extra Hard	—	B92	—	B92	B96
Shear Str, 1000 psi					
Annealed	—	41	—	41	—
Half Hard	—	47	—	50	—
Hard	—	52	—	55	—
Extra Hard	—	56	—	59	—
FABRICATING PROPERTIES					
Annealing Temp, F	1100–1500	1100–1500	1100–1500	1100–1500	1100–1500
Hot Workability	Poor	Poor	Poor	Poor	Poor
Cold Workability	Excellent	Excellent	Good	Excellent	Good
Machinability Index[b]	20	20	60	20	30
Joining	Soldering, excellent; silver alloy brazing, good to excellent; carbon arc welding, fair; resistance welding, excellent; oxyacetylene welding, good				
CORROSION RESISTANCE	Attacked rapidly by oxidizing acids. Resistant to sodium and potassium hydroxide but attacked rapidly by ammonium hydroxide and moist ammonia. Good resistance to rural and marine atmospheres and to fresh and salt waters. Subject to stress corrosion				
AVAILABLE FORMS	Sheet; strip; rods, bars, and shapes; wire; spring. Forging, extruding and casting alloys are also available				
USES	Most popular. Hardware, marine and automotive trim, camera parts, lighting fixtures, costume jewelry, screws, springs, slide fasteners	Slide fasteners, nameplates, decorative trim, camera parts	Key blanks, gears, pinions, screw machine parts, watch parts, camera and binocular parts, musical instrument parts	Rivets, screws, slide fasteners, optical parts, hollow ware, nameplates	Excellent for springs. Springs and contacts in telephone equipment, electrical controls. Resistance wire,, surgical and dental instruments, diaphragms, hardware

[a] 0.5% extension under load. [b] Based on free-cutting brass = 100.

Tin and Aluminum Brasses

Type →	Admiralty	Naval Brass	Leaded Naval Brass	Manganese Bronze (A)	Aluminum Brass
COMPOSITION, %	Cu 70.0–73.0, Sn 0.9–1.2, As, Sb, or P 0.10 max, Zn bal	Cu 59.0–62.0, Sn 0.5–1.0, Zn bal	Cu 59.0–62.0, Pb 1.25–2.25, Sn 0.5–1.0, Zn bal	Cu 57.0–60.0, Fe 0.8–2.0, Sn 0.5–1.5, Mn 0.5 max, Zn bal	Cu 76.0–79.0, Al 1.75–2.5, As, Sb, or P 0.10 max, Zn bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.308	0.304	0.305	0.302	0.301
Melting Temp Range, F	1650–1720	1630–1650	1630–1650	1590–1630	1710–1780
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	64	67	67	61	58
Coef of Ther Exp (68–572 F), per °F	11.2×10^{-6}	11.8×10^{-6}	11.8×10^{-6}	11.8×10^{-6}	10.3×10^{-6}
Spec Ht (68 F), Btu/lb/°F	0.09	0.09	0.09	0.09	0.09
Elec Res (68 F, annealed), microhm-cm	6.9	6.6	6.6	7.2	7.5
MECHANICAL PROPERTIES[a]					
Mod of Elast in Tension, psi	16×10^6	15×10^6	15×10^6	15×10^6	16×10^6
Ten Str, 1000 psi					
Annealed[b]	53	57	57	65	60
Quarter Hard	—	69	69	77	—
Half Hard	—	75	75	84	—
Yld Str, 1000 psi[b]					
Annealed	22	25	25	30	27
Quarter Hard	—	46	46	45	—
Half Hard	—	53	53	60	—
Elong (in 2 in.), %					
Annealed	65	47	40	33	55
Quarter Hard	—	27	20	23	—
Half Hard	—	20	15	19	—
Hardness (Rockwell)					
Annealed	F75	B55	B55	B65	F77
Quarter Hard	—	B78	B78	B83	—
Half Hard	—	B82	B82	B90	—
Shear Str, 1000 psi					
Annealed	—	40	36	42	—
Quarter Hard	—	43	39	47	—
Half Hard	—	44	40	48	—
FABRICATING PROPERTIES					
Cold Workability	Excellent	Fair	Poor	Poor	Excellent
Hot Workability	Fair	Excellent	Good	Excellent	Fair
Annealing Temp, F	800–1100	800–1100	800–1100	800–1100	800–1100
Machinability Index[c]	30	30	70	30	30
Joining					
Soft Soldering	Excellent	Excellent	Excellent	Excellent	Good
Silver Alloy Brazing	Good	Good	Good	Good	Good
Oxyacetylene Welding	Good	Good	Fair	Good	Good
Resistance Welding	Fair	Fair	Poor	Good	Good
CORROSION RESISTANCE	Good resistance to industrial, rural and marine atmospheres; petroleum products, alcohols, dry gases and sea water. Fairly good resistance to weak bases. Resistance to some weak bases and weak organic acids, but generally poor resistance to most acids and strong bases. Poor resistance to solutions of cyanides and ammonium compounds. Resistant to dezincification (especially Admiralty and Aluminum Brasses)				
AVAILABLE FORMS	Plate, wire, tube	Rolled strip, rolled and drawn bar, plate, rod, tube, shapes	Drawn bar, rod, shapes	Rod, shapes	Tube
USES	Condenser, evaporator and heat exchanger tubes; condenser tube plates; distiller tubes; ferrules	Aircraft turnbuckle barrels, balls, bolts, marine hardware, nuts, propeller shafts, rivets, valve stems, condenser plates, welding rods	Marine hardware, screw machine products, valve stems	Clutch disks, pump rods, shafting, balls, valve stems and bodies, welding rods	Condenser, evaporator and heat exchanger tubes, distiller tubes, ferrules

[a]Mechanical properties are based on 1-in. dia. Values for Admiralty and Aluminum Brasses apply to tube; other values apply to rod. [b]0.5% extension under load. [c]Based on free-cutting brass = 100.

Hafnium, Thorium, Uranium, Vanadium and Zirconium

Metal →	Hafnium	Thorium	Uranium	Vanadium	Zirconium
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.47	0.42	0.69	0.23	0.24
Melting Point, F	3400	3074	2071	3110	3355
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	21.4[a]	14.5[a]	—	9.6
Coef of Ther Exp (70 F), per °F	3.4×10^{-6}	6.2×10^{-6}	12.1×10^{-6}[b]	4.8×10^{-6}	3.1×10^{-6}
Spec Ht, Btu/lb/°F	0.035	0.03	0.03	0.12	0.069
Elec Res (68 F), microhm-cm	30[c]	18	25–50	25	40
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	20×10^6	10×10^6	30×10^6	20×10^6	14×10^6
Ten Str, 1000 psi					
Annealed	—	37.5	90	72	29[d], 59[e]
Cold Worked	—	—	—	113	82[d], 90[e]
Yld Str, 1000 psi					
Annealed	—	27	25	64	11[d], 38[e]
Cold Worked	—	—	—	109	58[d], 84[e]
Elong (in 2 in.), %					
Annealed	—	40	13	28	26[d], 27[e]
Cold Worked	—	—	—	3	1.5[d], 10[e]
Hardness (Rockwell)					
Annealed	B78[f]	—	—	B81	B42[d], B91[e]
Cold Worked	—	—	—	B93	B87[d]; B98[e]
FABRICATING PROPERTIES					
Annealing Temperature, F	1380 in vacuum or inert atm	—	—	1650 in vacuum or inert atm	1550; heavy sections in air, light sections in vacuum or inert atm
Workability	Can be hot worked at 1550 F; cold worked 30% between anneals	Can be readily hot or cold worked. Fabricated by forging, rolling, swaging, extruding or drawing	Can be forged, rolled, swaged and drawn. Heating must be done in a protective atm	Good cold working properties	Similar to titanium
Machinability	Similar to stainless steel	Can be machined like mild steel with or without cutting fluids	Moderately difficult to machine	Tools similar to those for cold rolled steel	Similar to titanium
Joining	—	Difficult to weld. Brazing yields brittle joints	Can be welded or brazed in protective atm or vacuum	Can be welded with heliarc torch under argon	Can be arc or flash-butt welded under inert atm
CORROSION RESISTANCE	Resistant to oxidizing acids but attacked by hydrofluoric acid	Very poor resistance to atmosphere, water and most reagents	Very poor resistance to atmosphere, water and most reagents	Resistant to sea water. Not affected by moderate concentration of hydrochloric and sulfuric acids. Dissolved by nitric acid of any strength	Excellent resistance to hydrochloric acid in all concentrations. Resists dilute sulfuric acid, nitric acid in all concentrations, and alkalis. Attacked by aqua regia
AVAILABLE FORMS	Has been produced in sheet and rod	Has been produced in rod, sheet, thin-walled tube, fine wire, foil	Has been produced in plate, rod, tube, wire and foil	Plate, strip, bar, sheet, wire	Sheet, rod, tubing, shapes
USES	No applications have been developed	Secondary (breeder) reactor fuel	Fissionable material (fuel) in nuclear reactor	AEC classified applications	Structural parts and fuel cladding in nuclear reactors. Probable future use: corrosion resisting equipment

[a] 70 F. [b] 70–250 F, parallel to A axis; 0.8×10^{-6} parallel to B axis; 12.9×10^{-6} parallel to C axis.
[c] 32 F. [d] Iodide zirconium; cold worked values are for 90% cold worked.
[e] Kroll zirconium, melted in graphite; cold worked values are for 60% cold worked. [f] As-deposited iodide hafnium.

Lead and Its Alloys (Soft)

Type ➡	Chemical Lead	Common Lead (soft lead)	Tellurium Lead
COMPOSITION, %	Pb 99.90+	Pb 99.73+	Te 0.05, Cu 0.06 max
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.41	0.41	0.41
Melting Point, F	618	621	617
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	19.6	19.6	19.3
Coef of Ther Exp, per °F	16.3×10^{-6}	16.3×10^{-6}	16×10^{-6}
Specific Heat (32 F), Btu/lb/°F	0.031	0.031	0.031
Electrical Resistivity (68 F), microhm-cm	—	20.6	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	2×10^6	2×10^6	1.5×10^6
Tensile Strength, psi			
Rolled	2450	2090	—
Extruded	2200	2000	—
Sand Cast	—	1800	—
Chill Cast	2200	2000	—
Yield Strength, psi			
Rolled	1640	—	—
Extruded	—	—	1500
Sand Cast	—	800	—
Elongation (in 2 in.), %			
Rolled	57	43	40
Extruded	48	—	—
Sand Cast	—	30	—
Chill Cast	40	47	—
Reduction of Area, %			
Sand Cast	—	100	—
Chill Cast	—	100	—
Hardness (Brinell)			
Extruded	—	—	6
Sand Cast	—	3.2–4.5	—
Chill Cast	—	4.2	—
Impact Strength (Charpy, chill cast), ft-lb	—	10	—
Endurance Limit (10^7 cycles), psi			
Extruded & Aged	725	470	1000
Sand Cast	—	470	—
Shear Strength, psi			
Sand Cast	—	1820	—
Chill Cast	—	1820	—
Creep Strength (0.1% per yr, rolled, 85 F), psi	300	250	300
FABRICATING PROPERTIES	Formed by cold rolling and extrusion		
Casting Temp Range, F	790–850	790–850	790–850
Joining	Soft solder with 50-50 or 40-60 solder using rosin or stearic acid flux. Oxyhydrogen welding (lead burning): slightly reducing flame; no flux		
CORROSION RESISTANCE	Resistant to sulfuric, sulfurous, phosphoric and chromic acids. Attacked by acetic, formic and nitric acids. Resistant to atmosphere and fresh and salt water		
AVAILABLE FORMS	Castings, rolled and extruded shapes, sheet		
USES	Chemical apparatus	Storage batteries, cable sheath, ammunition, calking, alloying, coatings, liquid baths for heat treating	Chemical apparatus

Lead and Its Alloys (Hard)

Type →	1% Sb-Lead	Hard Lead	Hard Lead	8% Sb-Lead	Grid Metal (7-12% Sb)
COMPOSITION, %	Sb 1	Sb 4	Sb 6	Sb 8	Sb 9
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.406	0.398	0.393	0.388	0.385
Melting Temp Range, F	608–595	570–486	545–486	520–486	509–486
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	19	18	17	16	16
Coef of Ther Exp (68–212 F), per °F	16×10^{-6}	15.5×10^{-6}	15.4×10^{-6}	14.5×10^{-6}	14.4×10^{-6}
Spec Ht, Btu/lb/°F	0.031	0.032	0.032	0.032	0.032
Elec Res (68 F), microhm-cm	22	24	25	26.5	27.1
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	2×10^6	—	—	—	—
Ten Str, 1000 psi					
Rolled	3.0	4.0	4.1	4.6	4.7
Extruded	2.9	3.1	3.3	3.3	—
Extruded & Aged	3.0	—	—	—	—
Chill Cast	3.4	5.6	6.8	7.4	7.4
Elong (in 2 in.), %					
Rolled	60	48	47	31	17
Extruded	58	58	65	75	—
Extruded & Aged	50	—	—	—	75
Chill Cast	16	22	24	19	—
Hardness (Brinell)					
Rolled	5.9	8	—	9.5	7.8
Extruded	5.1	8.9	10.7	12.4	—
Extruded & Aged	7	—	—	—	—
Chill Cast	7	10	11.8	13.3	15.4
Endurance Limit, psi[a]					
Rolled	—	1500	1500	1750	—
Extruded	—	—	1200	—	—
Extruded & Aged	1150	—	—	—	—
Chill Cast	—	—	2500	—	2700
Creep Str (86 F)[b]					
Rolled	—	250	400	425	400
Extruded	350	210	—	—	—
FABRICATING PROPERTIES					
Casting Temp Range, F	750–925	750–925	750–850	750–925	750–925
Joining	Soft solder with 50–50 or 40–60 solder using rosin or stearic acid flux. Oxyhydrogen welding (lead burning): no flux, slightly reducing flame				
CORROSION RESISTANCE	Similar to soft lead (see opposite page)				
USES	Cable sheathing	Rolled sheet for roofing and flashing; extruded pipe for corrosion resistance applications requiring greater strength than soft lead			Battery grids

[a] 2×10^7 cycles.
[b] 1% extension in 10,000 hr.

Magnesium Alloys

ASTM Type →	M1A	AZ31B-F	AZ61A-F	AZ80A-F
COMPOSITION, %	Mn 1.20 min	Al 2.5–3.5, Zn 0.6–1.4, Mn 0.20 min	Al 5.8–7.2, Zn 0.4–1.5, Mn 0.15 min	Al 7.8–9.2, Zn 0.2–0.8, Mn 0.12 min
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.063	0.064	0.065	0.066
Melting Temp Range, F	1200	1050–1170	950–1140	900–1115
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	79.9	43.6	33.8	29.0
Coef of Ther Exp, per °F				
65 to 212 F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}
65 to 750 F	16×10^{-6}	16×10^{-6}	16×10^{-6}	16×10^{-6}
Spec Ht (78 F), Btu/lb/°F	0.25	0.25	0.25	0.25
Elec Res (68 F), microhm-cm[b]	5.0	9.2	12.5	14.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi				
Extruded[b]	26–38	35–39	40–45	40–49[a]
Forged	36	—	43	46[a]
Yld Str, 1000 psi				
Extruded[b]	23–28	23–28	22–32	23–35[a]
Forged	23	—	26	31[a]
Elong (in 2 in.), %				
Extruded	8–11	12–18	15–16	10–12
Forged	7	—	12	8
Compr Yld Str, 1000 psi				
Extruded[b]	10–13	15–17	15–21	21–26[a]
Forged	—	—	18	25[a]
Hardness (Brinell)				
Extruded[b]	42–46	49–50	55–60	60–67
Forged	47	—	55	69
Shear Str, 1000 psi				
Extruded	16	19	21	21
Forged	16	—	21	22
Endurance Limit, 1000 psi				
Extruded	9	14	17	19
Forged	—	—	16	18
Impact Str (Charpy), ft-lb				
Extruded	2.1	3.2	3	2.2
Forged	—	—	2.2	1.8
THERMAL TREATMENT				
Annealing Temp, F	700	650	650	725
Stress Relief Temp, F[d]	500	500	500	400
Solution Temp, F	—	—	—	750
Aging Temp, F	—	—	—	350
FABRICATING PROPERTIES				
Hot Working Temp Range, F[c]	550–650	450–650	450–650	275–375
Weldability[e]				
Torch	A	B	C	D
Inert-Gas Arc	A	A	A	C
Elec Res	A	A	A	A
Machinability Index (free-cutting brass = 100)	500	500	500	500
Hot Formability[e]	A	A	B	C
Cold Formability	B	A	C	D
CORROSION RESISTANCE	High resistance to atmosphere			
AVAILABLE FORMS	Sheet, plate, rod, bar, extruded shapes, tubing, forgings		Rod, bar, extruded shapes, tubing, forgings	
APPLICATIONS	Airframe parts, textile machinery, truck bodies, jet engine parts			

[a]Tensile, tensile yield and compressive yield strengths, and hardness of AZ80A-F can be increased several per cent by heat treating, at some expense to elongation.
[b]Generally, strengths and hardness of extruded bar are highest, extruded tubing lowest, and extruded shapes intermediate in the ranges of values given.
[c]Higher working temperatures can be used if they do not require heating hard rolled or aged alloys above the annealing or aging temperature.
[d]For extrusions. [e]Letter A indicates most favorable, B less favorable, etc. Relative to magnesium alloys only.

Cast Magnesium Alloys

Type[a] →	AZ63A	M1B	AZ92A	AM100A	AZ91A
COMPOSITION, %	Al 5.3–6.7, Zn 2.5–3.5, Mn 0.15 min	Mn 1.20 min	Al 8.3–9.7, Zn 1.6–2.4, Mn 0.10 min	Al 9.3–10.7, Zn 0.3 max, Mn 0.10 min	Al 8.3–9.7, Zn 0.4–1.0, Mn 0.13, min
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.067	0.064	0.066	0.066	0.066
Melting Temp Range, F	850–1135	1200	830–1100	865–1100	875–1105
Ther Cond (212–572 F), Btu/hr/sq ft/°F/ft	29.0–38.7	—	26.6–33.8	24.2–36.3	26.6–31.5
Coef of Ther Exp (66–212 F), per °F	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}	14×10^{-6}
Spec Ht (78 F), Btu/lb/°F	0.25	0.25	0.25	0.25	0.25
Elec Res, microhm-cm					
As Cast	11.0	6.6	12.4	11.4	12.9
Solution Treated	14.0	—	16.8	17.2	16.2
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi					
As Cast	29	14	24	22	36
Sol'n Treated	40	—	40	40	—
Sol'n Treated & Aged	40	—	40	40	—
Yield Str, 1000 psi					
As Cast	14	4.5	14	12	23
Sol'n Treated	14	—	14	13	—
Sol'n Treated &. Aged	19	—	22	19	—
Elongation (in 2 in.), %					
As Cast	6	5	2	2	4
Sol'n Treated	12	—	10	10	—
Sol'n Treated & Aged	5	—	2	1	—
Hardness (Brinell)					
As Cast	50	33	65	53	60
Sol'n Treated	55	—	63	52	—
Sol'n Treated & Aged	73	—	83	69	—
Shear Str, 1000 psi					
As Cast	18	11	19	18	20
Sol'n Treated	19	—	20	20	—
Sol'n Treated & Aged	21	—	21	22	—
Endurance Limit, 1000 psi					
As Cast	11	—	11	10	14
Sol'n Treated	14	—	14	11	—
Sol'n Treated & Aged	13	—	13	10	—
Impact Str (Izod), ft-lb					
As Cast	3	9	1	2	2
Sol'n Treated	5	—	4	4	—
Sol'n Treated & Aged	2	—	1	2	—
THERMAL TREATMENT					
Solution Temp, F	730	—	760	790	—
Aging Temp, F	375	—	420	400	—
Stabilizing Temp, F	500	—	500	500	—
FABRICATING PROPERTIES					
Casting Temp, F					
Sand	1350–1550	1350–1550	1350–1550	1350–1550	—
Chill	1200–1500	—	1200–1500	1200–1500	1150–1250
Weldability[b,c]	D, D, A	A, A, A	D, A, A	D, A, A	—
Machinability Index[d]	500	500	500	500	500
CORROSION RESISTANCE					
Resistance to Atmosphere	Good	Good	Good	Good	Good
Resistance to Salt Water[b]	B	A	B	D	B
AVAILABLE FORMS	Sand castings	Sand castings	Sand and perm mold castings	Sand and perm mold castings	Die castings
USES	Parts for aircraft landing wheels and reciprocating and jet type engines. Vacuum cleaners, portable grinders and drills, foundry flasks, textile machinery, pistons. Various fittings				

[a]ASTM B80-55T, B199-55T and B94-54. [b]Letter A indiates most favorable, B less favorable, etc. Relative to magnesium alloys only. [c]Ratings for torch, inert-arc and electrical resistance methods in that order. [d]Based on free-cutting brass = 100.

Magnesium-Thorium and Magnesium-Zirconium Alloys

ASTM Type→	HM31X[a]	HM21A-T8[c]	HK31A	—	—	ZK60A-F
COMPOSITION, %	Th 2.5-3.5, Mn 1.2 min	Th 1.5-2.5, Mn 0.35-0.8	Zr 0.4-1, Th 2.5-4	Zn 0.75-1.5, Zr 0.5-1.0	Zn 2.5-4, Zr 0.5-1.0	Zn 4.8-6.2, Zr >0.45
PHYSICAL PROPERTIES						
Density, lb/cu in.	0.0651	0.0640	0.0647	0.064	0.065	0.0659
Melting Temp Range, F	1202-1121	1202-1121	1202-1092	—	—	1175-968
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	60	80	66	73	73	67
Coef of Ther Exp (68-400 F), per °F	10.5×10^{-6}	14.5×10^{-6}	14.5×10^{-6}	15.1×10^{-6}	15.1×10^{-6}	14.5×10^{-6}
Spec Ht, Btu/lb/°F	0.245	0.245	0.245	0.245	0.245	0.245
Elec Res (68 F), microhm-cm	6.6	5.1	6.4	5.8	5.8	6.0
MECHANICAL PROPERTIES[d]						
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi	—, —, 37	34, 33, —	37[c], —, —	36-45, —, 15-20	40-45, 45-49, 47-51	—, 49, 49[a]-52[b]
Yld Str (0.1% set), 1000 psi	—, —, 26	25, 20, —	29, —, —	24-27, —, 27-32	27-31, 31-33, 33-38	—, 38, 37[a]-42[b]
Elong (in 2 in.), %	—, —, 10	10, 15, —	8, —, —	8-18, —, —	8-18, 12-14, 15-25	—, 13, 13[a]-12[b]
Hardness (Vickers)	—, —, —	—, —, —	55, —, 55	55-75, —, 60-80	60-80, 60-80, 60-80	—, 75, 75
Impact Str (Izod), ft-lb	—, —, —	—, —, —	—, —, —	—, —, —	—, 3-5, 7-9	—, —, —
Fatigue Str, 1000 psi	—, —, —	—, —, —	—, —, —	—, —, 16.8	—, —, 19	—, —, —
Compr Yld Str, 1000 psi	—, —, 15	15, 17, —	23, —, —	—, —, 22-29	—, 20-29, 27-33	—, 28, 25-33
Creep Str (stress to give 0.5% ext in 100 hr), 1000 psi						
400 F	—	13.5	11	—	—	—
500 F	—	9.0	2.0	—	—	—
600 F	—	6.0	—	—	—	—
THERMAL TREATMENT						
Aging Temp, F	—	—	—	—	—	275 (48 hr)
FABRICATING PROPERTIES						
Hot Working Temp, F	650-800	650-800	650-700	500	500	300-500
Machinability (free-cutting brass = 100)	500	500	500	500	500	500
Weldability	Can be welded by inert-gas shielded arc methods and spot welding					Not weldable
CORROSION RESISTANCE	Good resistance to the atmosphere; attacked by salt water					
AVAILABLE FORMS	Extrusions	Sheet, plate, forgings	Sheet, plate	Sheet, extrusions, tubing	Sheet, forgings, extrusions	Extrusions, forgings
USES	High temp (600-850 F) aircraft service, missile components	High temp (600-900 F) aircraft service, missile components	High temp (600-800 F) aircraft service, missile components	Airframe parts, skins, ribs and spars, windows		

[a]As extruded. [b]Heat treated. [c]T8 temper for sheet, T5 temper for forgings.
[d]Mechanical properties given for sheet, forgings and extrusions, in that order.

Cast Magnesium-Thorium and Magnesium-Zirconium Alloys

ASTM Type[a] →	EZ33A	HZ32A	ZH62A	ZK51A
COMPOSITION, %	Zn 2.0-3.5, Zr 0.5 max, rare earths 2.5-4	Zn 1.7-2.5, Zr 0.5 min, Th 2.5-4	Zn 4.8-6.2, Zr 0.5 min, Th 1.4-2.2	Zn 3.5-5.5, Zr 0.5-1
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.0659	0.0659	0.0670	—
Melting Temp Range, F	1189-1010	1198-1026	1165-960	1185-1020
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	58	60	65	65
Coef of Ther Exp (68-400 F), per °F	14.9×10^{-6}	14.8×10^{-6}	14.8×10^{-6}	15.2×10^{-6}
Spec Ht, Btu/lb/°F	0.245	0.245	0.245	—
Elec Res (68 F), microhm-cm	7.0	6.5	6.6	6.6
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	6.5×10^6	6.5×10^6	6.5×10^6	6.5×10^6
Ten Str, 1000 psi	23	30	40	38
Yld Str, 1000 psi	15[b]	14[b]	25[c]	23.5[c]
Elong (in 2 in.), %	3	7	6	12
Hardness (Brinell)	50	57	70	75
Impact Str (Izod), ft-lb	1.5	2	1.5	3
Fatigue Str, 1000 psi[d]	8.3	10.5	11.8	12.3
Compr Yld Str (0.2% set), 1000 psi	10-15	10-14	25	24.5
Creep Str (stress for 0.5% ext in 1000 hr), 1000 psi				
400 F	8.4-10.1	8.7-11.5	—	—
500 F	—	7.4-9.8	—	—
600 F	1.4- 2.1	3.9-6.4	—	—
THERMAL TREATMENT				
Aging Temp, F	350 (16 hr)	600 (16 hr)	625 (2 hr) + 355 (16 hr)	360 (12 hr)
FABRICATING PROPERTIES				
Casting Temp Range, F	1380-1525	—	—	—
Machinability	All of these alloys have excellent machining properties			
Weldability	Can be welded by inert-gas shielded arc methods			
CORROSION RESISTANCE	Good resistance to the atmosphere; attacked by salt water			
USES	Pressure-tight castings; aircraft engine parts, expansion chambers, other parts for service at 300-500 F	Jet engine parts for service to 660 F	Structural castings for service to 400 F; engine parts, airframe parts	Structural castings for service to 300 F; engine parts, gear casings

[a]Mechanical properties given for sand castings. [b]0.2% set. [c]0.1% set. [d]50×10^6 reversals in Wohler type test.

Nickel and Its Alloys

Type →	A Nickel	Low Carbon Nickel	Duranickel
COMPOSITION, %	Ni 99.45, C 0.06, Mn 0.25, Fe 0.15, S 0.005, Si 0.05, Cu 0.05	Ni 99.55, C 0.01, Mn 0.20, Fe 0.15, S 0.005, Si 0.05, Cu 0.05	Ni 93.90, C 0.15, Mn 0.25, Fe 0.15, S 0.005, Si 0.55, Cu 0.05, Al 4.05, Ti 0.45
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.321	0.321	0.298
Melting Temp Range, F	2615–2635	2615–2635	2550–2620
Ther Cond (80–212F), Btu/hr/sq ft/°F/ft	36	36	10.7 (soft), 11.2 (age hardened)
Coef of Ther Exp (80–212 F), per °F	7.4×10^{-6}	7.4×10^{-6}	7.2×10^{-6}
Specific Heat (80–212 F), Btu/lb/°F	0.130	0.130	0.104
Electrical Resistivity (32 F), microhm-cm	9.5	9.5	46.5 (soft)
Magnetic Transformation Temp, F	680	680	120 (soft)
Magnetic?	Yes	Yes	Yes
MECHANICAL PROPERTIES[a]			
Modulus of Elasticity in Tension, psi	30×10^6	30×10^6	30×10^6
Tensile Strength, 1000 psi			
Annealed	55–75	50–60	90–120
Annealed, Age Hardened	—	—	160–190
Spring	90–130	—	155–190
Spring, Age Hardened	—	—	180–230
Yield Strength, 1000 psi			
Annealed	15–30	12–25	35–60
Annealed, Age Hardened	—	—	—
Spring	70–115	—	—
Spring, Age Hardened	—	—	—
Elongation (in 2 in.) %			
Annealed	55–40	60–40	50–130
Annealed, Age Hardened	—	—	25–10
Spring	15–2	—	10–2
Spring, Age Hardened	—	—	15–5
Hardness (Rockwell)			
Annealed	B64 (max)	B55 (max)	B90 (max)
Annealed, Age Hardened	—	—	C30–40
Spring	B95 (min)	—	C30–40
Spring, Age Hardened	—	—	C36–46
Endurance Limit (10^8 cycles), 1000 psi			
Hot Rolled	33	33	51
Hot Rolled, Age Hardened	—	—	52.5
Cold Drawn	50	50	51
Cold Drawn, Age Hardened	—	—	61
THERMAL TREATMENTS			
Annealing Temperature, F	1500 (2–5 min)	1500 (3–6 min)	1600 (2–5 min)
Aging Temperature, F	—	—	1100 (8–16 hr)
FABRICATING PROPERTIES			
Hot Working Temp Range, F			
Heavy Forging, Drop Forging	1600–2300	1400–2300	1900–2300
Light Forging	1200–1600	1200–1600	1600–1900
Joining	Metallic arc, inert-gas metal arc, oxyacetylene and resistance welding; silver and copper brazing; soft soldering		Metallic arc, inert-gas metal arc and resistance welding; silver brazing; soft soldering
AVAILABLE FORMS	Sheet, strip; rods, bars and shapes; tube; plate		
USES	Generally used in process equipment for resistance to corrosion and high temperatures. Also used in electronic equipment for vacuum tube parts, leads and springs	Equipment for production and handling of molten caustic soda and other molten salts. Spun or coined parts. Long time service at 700–1200 F	Parts requiring corrosion resistance and strength at elevated temperatures, such as springs, dies for extruding plastics, fasteners, vacuum tube components

[a]Values are for sheet and strip unless otherwise specified.

Nickel and Its Alloys—concluded

Type →	Monel	K Monel	Inconel	Inconel X
COMPOSITION, %	Ni 66.00, C 0.12, Mn 0.90, Fe 1.35, S 0.005, Si 0.15, Cu 31.50	Ni 65.30, C 0.15, Mn 0.60, Fe 1.00, S 0.005, Si 0.15, Cu 29.50, Al 2.80, Ti 0.50	Ni 76.40, C 0.04, Mn 0.20, Fe 7.20, S 0.007, Si 0.20, Cu 0.10, Cr 15.85	Ni 72.80, C 0.04, Mn 0.70, Fe 6.75, S 0.007, Si 0.30, Cu 0.05, Cr 15.15, Al 0.80, Ti 2.55, Cb+Ta 0.85
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.319	0.306	0.304	0.298
Melting Temp Range, F	2370–2460	2400–2460	2540–2600	2540–2600
Ther Cond (80–212 F), Btu/hr/sq ft/°F/ft	15	10.8	8.7	8.7
Coef of Ther Exp (77–212 F), per °F	7.8×10^{-6}	7.8×10^{-6}	6.4×10^{-6}	9×10^{-6}
Spec Heat (70–750 F), Btu/lb/°F	0.127	0.127	0.109	0.10–0.11
Elec Res (68 F), microhm-cm	48.2	58.3	98.1	124.6 (122 F)
Magnetic?	Slightly magnetic	Nonmagnetic to −150 F	Nonmagnetic	Nonmagnetic
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension, psi	26×10^6	26×10^6	31×10^6	31×10^6
Ten Str, 1000 psi				
Annealed	70–85	90–105	80–100	110–130
Annealed, Age Hardened	—	130–170	—	155–180
Spring	100–140	145–165	145–170	200–225
Spring, Age Hardened	—	170–200	—	250–285
Yld Str (0.2% offset), 1000 psi				
Annealed	25–45	40–65	30–45	45–65
Annealed, Age Hardened	—	90–120	—	100–125
Spring	90–130	130–160	120–160	230–240
Spring, Age Hardened	—	130–180	—	260–290
Elong (in 2 in.), %				
Annealed	50–35	45–25	55–35	40–55
Annealed, Age Hardened	—	25–15	—	30–20
Spring	15–2	8–3	10–2	1.6 (approx)
Spring, Age Hardened	—	10–5	—	1
Hardness (Rockwell)				
Annealed	B68 (max)	B85 (max)	B84 (max)	B95 (max)
Annealed, Age Hardened	—	C24–33	—	C30–37
Spring	B98 (min)	C25–32	C30 (min)	—
Spring, Age Hardened	—	C34–40	—	—
THERMAL TREATMENTS				
Annealing Temp, F	1600–1800 (open), 1400–1500 (box)	1400–1800 (1–5 min)	1600–1800	1900–2000 (15–30 min)
Solution Temp, F	—	—	—	2100 (2–4 hr, a.c.[c])
Aging Temp, F	—	1100 (8–16 hr, f.c.[c])	—	1550 (24 hr, a.c.), 1300 (20 hr, a.c.[c])
FABRICATING PROPERTIES				
Hot Working Temp Range (hot forging, drop forging), F	1700–2150	1900–2150	1700–2300	1800–2200
Cutting Speed, fpm[b]	125–225	100–200	100–175	—
Joining Methods	Metal arc, inert-gas metal arc, oxyacetylene and resistance welding; silver and copper brazing; soft soldering		Metal arc, inert-gas metal arc and resistance welding; silver brazing	
AVAILABLE FORMS	Sheet, strip, rod, bar, shapes, tube, plate			Sheet rod, bar, shapes
USES	Applications requiring combination of good strength, ductility and corrosion resistance. Condenser and heat exchanger tubes; pickling baskets, hooks and rods; pump shafts; valve stems; springs; fasteners	Applications requiring greater strength and hardness than monel with same corrosion resistance and strength comparable with that of mild steel. Pump shafts and liners, valve seats and stems, electrical contact arms	Food processing equipment, such as cookers, kettles, steamers and storage tanks. Other process equipment requiring similar combination of strength, corrosion resistance and good elevated temperature properties	High strength, high temperature alloy (can operate extended periods at 1000 F) for application in steam turbines, jet engines, heat treating equipment. Furnace muffles, springs, turbine blades, bellows, fasteners

[a]Values are for sheet and strip unless otherwise specified. [b]Surface speed with single point cemented carbide tools.
[c]a.c.—air cool, f.c.—furnace cool.

Cast Nickel Alloys

Type ➡	Nickel	Inconel	S Inconel	Monel	S Monel
COMPOSITION, %	Ni 95.6, Cu 0.5, Fe 0.5, Si 1.5, Mn 0.8, C 0.80, S 0.008	Ni 71.5, Cu 0.50, Fe 8.0, Cr 16.0, Si 2.0, Mn 1.0, C 0.20, S 0.008	Ni 68.0, Cu 0.5, Fe 8.5, Mn 1.0, Si 5.5, Cr 15.5, S 0.008, C 0.20	Ni 63.0, Cu 32.0, Fe 1.5, Si 1.6, Mn 0.75, C 0.15, S 0.015	Ni 63.0, Cu 30.0, Fe 2.0, Si 4.0, Mn 0.75, C 0.1, S 0.015
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.301	0.300	0.292	0.312	0.302
Melting Temp Range, F	2450–2600	2500–2550	—	2400–2450	2300–2350
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	34.2	8.7	—	15.5	11.3
Coef of Ther Exp (70–1400 F), per °F	8.85×10^{-6}	8.92×10^{-6}	9.20×10^{-6}	9.0×10^{-6}	8.7×10^{-6}
Spec Ht (80–750 F), Btu/lb/°F	0.13	0.11	—	0.13	0.13
Elec Res (32 F), microhm-cm	20.8	11.6	12.6	53.2	63.1
Magnetic Trans Temp, F	680	–40	—	110–140	–70
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	21.5×10^6	23×10^6	25×10^6	23.0×10^6	24.2×10^6
Mod of Elast in Torsion, psi	11.0×10^6	11.0×10^6	—	9.5×10^6	9.5×10^6
Ten Str, 1000 psi					
Annealed & Aged	—	—	75–30	—	120–145
As Cast	50–65	65–90	90–120	65–90	120–145
Yld Str (0.5% ext), 1000 psi					
Annealed & Aged	—	—	55–70	—	85–130
As Cast	15–30	—	80–100	32–45	80–130
Elong (in 2 in.), %					
Annealed & Aged	—	—	4–1	—	1–4
As Cast	30–15	20–10	3–1	20–50	1–4
Hardness (Brinell)					
Annealed & Aged	—	—	300–380	—	300–380
As Cast	90–130	150–300	300–380	125–150	275–350
Impact Str (Charpy, rm temp), ft-lb	90–75	24	—	80–65	9–3
FABRICATING PROPERTIES					
Pouring Temp, F	2700–2900	2800–2950	2700–2900	2700–2850	2650–2800
Pattern Shrinkage, in./ft	0.25	0.25	0.25	0.25	0.25
Weldability	Fabrication or repair by any standard process[a]	Repair welding by any standard process[a]	Not recommended	Limited amount of repair welding[a]	Not recommended
CORROSION RESISTANCE	Good corrosion resistance, especially to hot concentrated caustic soda, and chlorine and fluorine gases	Resistance to nitric acid, ammonium hydroxide and oxidizing conditions superior to that of nickel. Good resistance to oxidation at temperatures up to 2200 F. Good resistance to corrosive vapors above 800 F		Good resistance to flowing salt water; dilute acids; hydrochloric, hydrofluoric, sulfuric, phosphoric and most organic acids; and strong caustic soda. Not resistant to strongly oxidizing solutions such as nitric acid and ferric chloride	
USES	Evaporators, tanks, heating coils, tubular condensers and other processing equipment; magnetostrictive devices; applications in incandescent lamp and radio industries	Dairy equipment, food handling equipment, airplane exhaust manifolds, utensils. Used extensively in oxidizing and carburizing atmospheres at elevated temperatures. Inconel S castings have higher resistance to wear and galling than Inconel		Valve seats, liners, pump rods, bushings, nozzles, turbine blading, pickling equipment, laundry machines, paper mill and oil refinery equipment, food handling equipment, storage tanks, boilers. Monel S castings have higher resistance to galling and erosion than Monel	

[a]For joining by welding, a weldable grade is available.

Low Expansion Nickel Alloys

Composition (%)[a] →	Ni 36	Ni 42	Ni 47-50
PHYSICAL PROPERTIES			
Density, lb/cu in.	0.292	0.292	0.296
Melting Point, F	2600	2606	2600
Ther Cond (68–212 F), Btu/hr/sq ft/°F/ft	6.05	6.21	6.91
Coef of Ther Exp, per °F			
–200 to 0 F	1.10×10^{-6}	3.42×10^{-6}	5.37×10^{-6}
0 to 200 F	0.70×10^{-6}	3.18×10^{-6}	5.55×10^{-6}
200 to 400 F	1.50×10^{-6}	2.97×10^{-6}	5.55×10^{-6}
400 to 600 F	6.35×10^{-6}	3.15×10^{-6}	5.55×10^{-6}
600 to 800 F	8.61×10^{-6}	5.50×10^{-6}	5.60×10^{-6}
800 to 1000 F	9.48×10^{-6}	8.55×10^{-6}	7.26×10^{-6}
Specific Heat (77–212 F), Btu/lb/°F	0.123	0.121	0.120
Electrical Resistivity (68 F), microhm-cm	81	70	48
Poisson's Ratio	0.290	0.290	0.290
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	21×10^6	22×10^6	24×10^6
Tensile Strength, 1000 psi			
Annealed	70	76	82
Cold Worked	90	120	140
Yield Point, 1000 psi			
Annealed	24	28	31
Cold Worked	70	—	—
Elongation (in 2 in.), %			
Annealed	36	38	41
Cold Worked	20	—	—
Reduction of Area, %			
Annealed	68	70	72
Cold Worked	60	—	—
Hardness			
Annealed (Brinell)	143	156	170
Cold Worked (Rockwell)	—	B100	B103
Modulus of Rigidity, psi	8.1×10^6	8.5×10^6	9.3×10^6
FABRICATING PROPERTIES			
Annealing Temp, F	Soften progressively in range 1000 to 2300 F		
Hot Working Temp Range, F	To 2300 F	To 2300 F	To 2300 F
Machinability	Machine best at a hardness of about Rockwell C20		
Weldability	Can be welded by acetylene torch, metal arc, carbon arc and resistance methods		
CORROSION RESISTANCE	Resistant to atmospheric corrosion and to fresh and salt water		
AVAILABLE FORMS	Bar, plate, sheet, strip, wire, tubing, forgings, castings		
USES	Length standards, instruments, hypodermic syringes, textile machine parts, thermostatic bimetal — up to 400 F	Higher temperature thermostatic bimetal, instruments, glass sealing — up to 650 F	Higher temperature low expansion applications—up to 1000 F

[a] Balance iron.

Precious Metals

Metal →	Gold[a]	Silver[b]	Platinum[c]	Palladium[b]
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.698	0.379	0.775	0.434
Melting Point, F	1945	1761	3224	2829
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	172	242	42	41
Coef of Ther Exp (32–212 F), per °F	7.9×10^{-6}	10.9×10^{-6}	4.9×10^{-6}	6.5×10^{-6}[a]
Spec Ht, Btu/lb/°F	0.031	0.056	0.031	0.058
Elec Res (32 F), microhm-cm	2.35	1.59[d]	14.9	10.8[a]
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	12×10^6	11×10^6	21×10^6	17×10^6
Ten Str, 1000 psi				
Annealed	19	22	17–26	30
Cold Worked	32[e]	54[f]	34–45	47
As Cast	18	15	—	—
Yld Str, 1000 psi				
Annealed	Nil	8	2–5.5	5
Cold Worked	30	44	27	30
As Cast	—	5	—	—
Elong (in 2 in.), %				
Annealed	45	48	30–40	24–40
Cold Worked	4	2.5	2.5–3.5	1.5
As Cast	30	60	—	—
Red. of Area (as cast), %	—	67	—	—
Hardness (Brinell)				
Annealed	25	25–35	38–52	46
Cold Worked	58	—	97–13	109
As Cast	33	42	—	—
Endurance Limit (10^7 cycles, annealed), 1000 psi	4.6	—	—	—
FABRICATING PROPERTIES				
Annealing Temp, F	—	400–600	1475–2200	1475
Hot Working Temp Range, F	Any to melting point	—	1475–2300	1475–2300
Max Red. Between Anneals, %	Apparently unlimited	—	99	99
Casting Temp Range, F	2000–2370	2000	3300	3000
Joining	Braze with silver solder, no flux, any flame. Can be resistance welded by any method. Oxyacetylene weld with no flux, any flame	Braze with silver solder. Can be resistance welded	Braze with fine gold or white platinum solder. Hammer weld at 1800 F. Can be resistance or oxyacetylene welded	Braze with oxyacetylene torch using platinum solders. Can be resistance welded
CORROSION RESISTANCE	Does not oxidize when heated in air. Resists alkalis, salts and most acids. Not attacked by oxygen or sulfur. Rapidly attacked by chlorine and bromine	Does not oxidize when heated in air. Resists most dilute mineral acids and alkalis. Attacked rapidly by nitric and hot sulfuric acids. Attacked rapidly by sulfur-bearing gases	Does not oxidize when heated in air. Resists reducing or oxidizing acids alone but is dissolved by aqua regia	Oxidizes when heated in air. Resists hydrofluoric, acetic and phosphoric acids. Attacked by nitric, sulfuric and hydrochloric acids; and bromine and iodine
AVAILABLE FORMS	Foil, rod, wire, sheet	Sheet, strip, rod, wire, tubing	Foil, sheet, wire, tubing	Sheet, foil, wire, tubing
USES	Lining of chemical equipment, high melting solder, alloys for electrical and chemical purposes, jewelry, dentistry	Electrical contacts, corrosion resisting equipment, bearings, photography supplies; alloying for coinage, brazing alloys, jewelry	Chemical equipment, electrical contacts, catalysts, laboratory equipment, jewelry	Electrical contacts, catalysts, production of pure hydrogen, jewelry, dental alloys

[a]Gold is generally produced in three grades: proof gold, 99.99% Au; refined gold, 99.95-99.98% Au; and 99.5% Au, which is accepted by the U.S. Mint without penalty.
[b]Usually refined to "the high purity suitable for general use"; in some cases spectographically pure.
[c]Platinum is produced in four grades: type A, 99.99% Pt, sometimes called physically pure; type B, 99.9% Pt, sometimes called chemically pure; type C, 99.5% Pt (crucible grade); and type D, 99% Pt (commercial platinum).
[d]68 F. [e]Cold rolled, 60% reduction. [f]Cold rolled, 50% reduction.

Precious Metals—concluded

Metal →	Rhodium[b]	Ruthenium[b]	Osmium[b]	Iridium[b]
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.447	0.441	0.82	0.813
Melting Point, F	3571	4530	4890	4450
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	50	—	—	34
Coef of Ther Exp (68 F), per °F	4.6×10^{-6}	5.1×10^{-6}	3.6×10^{-6}	3.8×10^{-6}
Specific Heat, Btu/lb/°F	0.059	0.057	0.031	0.031
Elec Res (68 F), microhm-cm	4.51	7.6[g]	9.5	5.3
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	42×10^6	60×10^6	80×10^6	74×10^6
Ten Str, 1000 psi				
Annealed	73	—	—	—
Cold Worked	300	—	—	—
Hardness (Brinell)				
Annealed	55–156	—	—	170
Cold Worked	260–390	—	—	350
As Cast	—	220	350	163
FABRICATING PROPERTIES				
Hot Working Temp Range, F	1900–2000	2700–4300	Not workable	2200–2700
Max Red. Between Anneals, %	30–40	—	—	—
Casting Temp, F	3700	4700	5000	4600
Joining	Can be brazed and resistance welded	Can be brazed and resistance welded	Can be brazed and resistance welded	Can be brazed and resistance welded
CORROSION RESISTANCE	Oxidizes slowly when heated in air. Resistant to most acids, including aqua regia at room temperature	Oxidizes when heated in air. Unattacked by common acids, including aqua regia up to 212 F. Moderately attacked by solutions of alkaline hypochlorites	Oxidizes rapidly in air at elevated temperatures. Resists common acids at room temperatures, but is attacked by aqua regia	Oxidizes slowly when heated in air. Unattacked by common acids, including aqua regia up to 212 F
AVAILABLE FORMS	Powder	Powder	Cast or sintered parts	Sheet, wire, rod
USES	Mirrors and electrodeposits for a nontarnishing finish; alloys with platinum and palladium for crucibles, glassworking equipment, catalysts, spinnerets	Hardener for platinum and palladium	Alloys used for pen tips, phonograph needles, electrical contacts, instrument pivots	Extrusion dies for glass, alloys with platinum for electrical contacts, fuse wires, hypodermic needles, jewelry

[b]Usually refined to "the high purity suitable for general use"; in some cases spectrographically pure.
[g]At 32 F.

Tin and Its Alloys

Type ➡	Grade A Tin	Hard Tin	Tin Foil	White Metal	Pewter
COMPOSITION, %	Sn 99.8 min	Sn 99.6, Cu 0.4	Sn 92, Zn 8	Sn 92, Sb 8	Sn 91, Sb 7, Cu 2
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.264	—	—	0.262	0.263
Melting Temp Range, F	449.4	446–441	390	475	563–471
Ther Cond (77 F), Btu/hr/sq ft/°F/ft	37	—	34	—	—
Coef of Ther Exp (32–212 F), per °F	13 x 10^{-6}	—	—	—	—
Spec Ht, Btu/lb/°F	0.054	—	—	—	—
Elec Res (68 F), microhm-cm	11.5	—	12	15	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	6–6.5 x 10^6	—	—	—	7.7 x 10^6
Ten Str, 1000 psi					
Annealed Sheet	2.2	3.3	—	6.7	8.6
Cold Rolled Sheet	2.8	4.0	8.7	7.4[b]	7.6
As Cast	2.1	—	—	7.2[c]	—
Yld Str, 1000 psi					
Annealed Sheet	1.3	—	—	—	—
Cold Rolled Sheet	2.0	—	6.0	—	—
As Cast	1.7	—	—	—	—
Elong (in 2 in.), %					
Annealed Sheet	45	—	—	70	40
Cold Rolled Sheet	35	—	40	28[b]	50
As Cast	55[a]	—	—	—	—
Hardness (Brinell)					
Annealed Sheet	7	—	—	17	13[d, f]
Cold Rolled Sheet	8	—	—	—	18[e, f]
As Cast	5–6	—	—	20[c]	23[d, f]
Impact Str (Izod, as cast), ft-lb	14	—	—	22[c]	—
Endurance Limit (as cast), 1000 psi	0.34	—	—	—	—
FABRICATING PROPERTIES					
Casting Temp Range (chill), F	525–550	525–550	—	575–600	600–625
Joining	Bonds easily by simple melting. Eutectic tin-lead solder or low melting fusible alloys might be used on massive parts such as block tin pipe		—	Readily soldered	Can be soldered with some of the fusible alloys
CORROSION RESISTANCE	Resists distilled, sea and soft tap water. Attacked by strong acids, alkalis and acid salts. Oxygen in solution accelerates rate of attack		—	—	Tarnishes in soft water; suffers localized attack at water line in hard water. Attacked by dilute hydrochloric and citric acids in presence of air
AVAILABLE FORMS	Sheet, pipe, foil, castings, powder	Tubing, foil	Foil	Castings, sheet	Castings, sheet
USES	Linings for food cans; pipe for handling water, beer, and carbonated beverages; linings for food processing equipment, food wrappings	Collapsible tubes, foil	Foil for wrapping food, medicines, electrical condensers	Rubber mold castings, cast and wrought costume jewelry	Mountings and ornamental objects such as tea and coffee services, vases and book ends

[a] In 4 in.
[b] Sheet quenched from 425 F.
[c] Chill cast.
[d] Vickers pyramid hardness.
[e] Vickers pyramid hardness after heat treating 3 hr at 300 F.
[f] Hardenable pewter values are: 13, 28, 29, respectively.

Lead-Tin-Antimony Alloys

Grade[a] ➡	1[b]	2	3	4	5[c]
COMPOSITION, %	Sn 91, Sb 4.5, Cu 4.5	Sn 89, Sb 7.5, Cu 3.5	Sn 84, Sb 8, Cu 8	Sn 75, Pb 10, Sb 12, Cu 3	Sn 65, Pb 18, Sb 15, Cu 2
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.265	0.267	0.269	0.272	0.280
Melting Temp Range, F	433–700	466–669	464–792	363–583	358–565
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	7.3×10^6	7.6×10^6	—	—	—
Ten Str, 1000 psi					
Chill Cast	9.3	11	10–12	—	—
Die Cast	10.3	—	—	—	11.8
Elong (in 2 in., die cast), %	22	—	—	—	4
Hardness (Brinell)					
Chill Cast	17	24	27	25	22
Die Cast	—	—	—	—	27.7
Impact Str (Izod, chill cast), ft-lb	2.5	—	1	—	—
Endur Limit (chill cast), 1000 psi	3.8[d]	4.8[d]	—	—	—
Compr Str (chill cast, 25% set), 1000 psi	13	15	18	16	15
Compr Yld Str (chill cast, 0.125% set), 1000 psi	4.4	6.1	6.6	5.5	5.0
FABRICATING PROPERTIES					
Casting Temp Range (chill), F	750–825	795	850–915	710	690–700
CORROSION RESISTANCE	Resists oxidation products of lubricants; food products, beer and carbonated beverages	Resist oxidation products of lubricants			
AVAILABLE FORMS	Precision inserts of babbitt-lined strip, lined bearing shells, ingots, die castings			Ingots	Ingots, die castings
USES	Bearings, die castings for dairy machinery, dental appliances, surgical instruments, soda fountain equipment	Most widely used tin-base bearing alloy in automotive field	High load applications, hardest of standard tin babbitts and has greatest load carrying capacity	Limited bearing applications	Limited bearing applications Die cast parts

[a] ASTM B23-49.
[b] Also die casting Alloy 1, ASTM B102-48.
[c] Also die casting Alloy 3, ASTM B102-48.
[d] 2×10^7 cycles.

continued

Lead-Tin-Antimony Alloys—continued

Grade[a] →	6	7	8	10	11
COMPOSITION, %	Sn 20, Sb 15, Pb 63.5, Cu 1.5	Sn 10, Sb 15, Pb 75	Sn 5, Sb 15, Pb 80	Sn 2, Sb 15, Pb 83	Sb 15, Pb 85
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.336	0.350	0.361	0.362	0.370
Melting Temp Range, F	531–358	514–464	522–459	507–468	504–471
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	14	14	—	—
Coef of Ther Exp (68–212 F), per °F	—	10.9×10^{-6}	13×10^{-6}	—	—
Spec Ht, Btu/lb/°F	—	0.065	0.065	—	—
Elec Res (68 F), microhm-cm	—	28.6	28.2	—	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	—	4.2×10^6	4.2×10^6	—	—
Ten Str, 1000 psi[e]	—	10.5	10	—	6.8
Elong (in 2 in.), %[e]	—	4	5	—	8
Hardness (Brinell)[e]	21	22	20	18	15
Endurance Limit, 1000 psi[e]	—	4[d]	3.9[d]	—	—
Compr Str (25% deformation), 1000 psi[e]	14.5	15.6	15.6	15.4	12.8
Compr Yld Str (0.125% set), 1000 psi[e]	3.8	3.6	3.4	3.4	3.0
FABRICATING PROPERTIES					
Casting Temp (chill), F	655	640	645	630	630
CORROSION RESISTANCE	Resistant to corrosion by the usual lubricants				
AVAILABLE FORMS	Small ingots and bars				
USES[f]	General purpose bearing applications	General purpose bearings under moderate loads	Bearings for light loads and moderate speeds. Mining machinery, transmission machinery, car journals	Bearings for light loads and speeds. Blowers, pumps, electric motors, machine tools	Bearings for light loads

[a]ASTM B23–49.
[d]2×10^7 cycles.
[e]Chill cast.
[f]Light loads—under 1000 psi; moderate loads—1000 to 2000 psi; heavy loads—over 3000 psi. Surface speeds: low—to 10 fps; moderate—to 20 fps; high—above 30 fps.

Lead-Tin-Antimony Alloys—concluded

Grade[a] →	12	15	16	19
COMPOSITION, %	Sb 10, Pb 90	Sn 1, Sb 15, Cu 0.5, As 1.0, Pb bal	Sn 10, Sb 12.5, Cu 0.5, Pb bal	Sn 5, Sb 9, Pb bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.384	0.362	0.355	0.378
Melting Temp Range, F	498–473	538–479	495–471	495–462
Coef of Ther Exp (68–212 F), per °F	14.6×10^{-6}	—	—	—
Specific Heat, Btu/lb/°F	0.065	—	—	0.065
Elec Res (68 F), microhm-cm	25.6	—	—	28.7
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	—	4.2×10^6	—	4.2×10^6
Tensile Strength, 1000 psi[e]	—	10.4	—	10
Elongation (in 2 in.), %[e]	—	2	—	5
Hardness (Brinell)[e]	14	21	28	18
Endurance Limit, 1000 psi[e]	—	4.3[d]	—	3.7[f]
Compressive Strength (25% deformation), 1000 psi[e]	12.9	—	—	15.6
Compressive Yield Strength (0.125% set), 1000 psi[e]	2.8	—	—	—
FABRICATING PROPERTIES				
Casting Temp (chill), F	625	660	620	620
CORROSION RESISTANCE	Resistant to corrosion by the usual lubricants			
AVAILABLE FORMS	Small ingots and bars			
USES[f]	Bearings for light loads	Bearings for high loads and speeds. Diesel engines, automotive engines, steamships, various types of machines	Bearings for moderate loads and speeds	Bearings for light loads and speeds. Car journal bearings

[a] ASTM B23–49.
[e] Chill cast.
[f] Light loads—under 1000 psi; moderate loads—1000 to 2000 psi; heavy loads—over 3000 psi. Surface speeds: low—to 10 fps; moderate—to 20 fps; high—above 30 fps. 2×10^7 cycles.

Titanium and Its Alloys

Type →	Unalloyed	3 Al–5 Cr	5 Al–2.5 Sn	6 Al–4V
COMPOSITION, %	Ti 99.0	Al 3.0, Cr 5.0	Al 5.0, Sn 2.5	Al 5.5–6.3, V 3.5–4.5
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.163	0.166	0.161	0.160
Melting Temp Range, F	3135	—	2822–3002	—
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	9.8	—	4.85	—
Coef of Ther Exp (68–1650 F), per °F	5.8×10^{-6}	6.1×10^{-6}	5.7×10^{-6}	5.8×10^{-6}
Spec Ht (212 F), Btu/lb/°F	0.130	—	0.131	—
Elec Res (68 F), microhm-cm	55.0	150	157.3	—
Magnetic Permeability (20 oersteds)	1.00005	—	1.00005	—
MECHANICAL PROPERTIES[a]				
Mod of Elast in Tension (200 F), psi	$15–15.5 \times 10^6$	—	15.5×10^6	—
Ten Str (68 F), 1000 psi				
Annealed	89–100	155	125	130–140
Heat Treated	—	—	—	170
Yld Str (68 F), 1000 psi				
Annealed	80–82	145	120	120–130
Heat Treated	—	—	—	150
Elong (in 2 in.), %				
Annealed (68 F)	15–22	13	18	10–13
Heat Treated	—	—	—	13
Red. of Area (68 F), %				
Annealed	40–45	35	40	25–40
Heat Treated	—	—	—	40
Hardness (Rockwell)				
Annealed	C30	C32	C30–35	C33–36
Heat Treated	—	—	—	C38
Impact Str (Charpy, 68 F), ft-lb	20–35	13	18–20	15–25
Endurance Limit (10^8 cycles), 1000 psi				
Bar (unnotched)	60–62	85	—	70
Bar (notched)	37[b]	—	—	35
Sheet (unnotched)	43	—	95	—
Sheet (notched)	—	—	36[c]	—
Mod of Rigidity (200 F), psi	5.63	—	—	—
Shear Str, 1000 psi	65	—	—	—
THERMAL TREATMENT				
Annealing Temp, F	850–1250	—	1500–1600	—
Stress Relieving Temp, F	700–1000	—	1000–1200	—
FABRICATING PROPERTIES				
Hot Working Temp Range, F	300–800	—	1000	—
Deep Drawing Temp, F	800	—	—	—
Forging Temp, F	1300–1600	—	1400–1900	—
Fusion Weldability	Yes	No	Yes[d]	Marginal
Formability (sheet, 78 F)[e]	High	Bar only	Intermediate	Intermediate
CORROSION RESISTANCE	Superior resistance to nitric acid, moist chlorine, chlorine solutions, chlorinated organic compounds and inorganic chloride solutions. Excellent resistance to sea water and most chloride salt solutions unchallenged by other structural metals. Resist impingement, pitting attack			
AVAILABLE FORMS	Sheet, strip, plate, tubing, billets, bar, wire	Bar, forgings	Sheet, strip, plate, billets, bar, wire	Bar, sheet, strip
USES	Military aircraft parts requiring corrosion resistance and high strength-to-weight ratio up to 800 F. Naval and marine applications; chemical, pharmaceutical and food processing and handling equipment; marine diesel engine mufflers; springs (high proportional limit and low modulus of elasticity), rivets, bolts, nuts, screws and fittings; ordnance and sporting equipment; orthopedic and orthodontic equipment			

[a]Annealed condition unless otherwise stated. [b]60-deg notch, 0.010-in. radius, k = 2.7. [c]k = 4.0.
[d]Some users report difficulty in producing welds without porosity; others do not.
[e]All titanium sheet is formed with considerably less difficulty at elevated temperatures. Forming can be accomplished at temperatures in the 500 to 1000 F range with no need for postforming surface treatment, provided time at temperature is short.

Titanium and Its Alloys—concluded

Type →	2.2 Fe–2.1 Cr–2.0 Mo	8 Mn	3 Mn–1.5 Al	4 Mn–4 Al
COMPOSITION, %	Cr 1.8–2.4, Fe 1.9–2.5, Mo 1.7–2.3	Mn 7.9	Al 1.5, Mn 3.0	Al 4.0, Mn 4.0
PHYSICAL PROPERTIES				
Density, lb/cu in.	—	0.170–0.172	0.168	0.163–0.165
Melting Temp Range, F	—	2730–2970	—	2822–3002
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	—	6.7	—	4.9
Coef of Ther Exp (68–1650 F), per °F	—	7.1×10^{-6}	—	$5.7–6.3 \times 10^{-6}$
Spec Ht (68 F), Btu/lb/°F	—	0.118	—	0 133
Elec Res (68 F), microhm-cm	79	90.7	—	146.1
Magnetic Permeability (20 oersteds)	—	1.00005	—	1.00005
MECHANICAL PROPERTIES[a]				
Mod of Elasticity in Tension (200 F), psi	—	15.9×10^6	15×10^6	15.9×10^6
Ten Str, 1000 psi	120–130	126–135	125	145–150
Yld Str, 1000 psi	110–115	118–120	116	135–142
Elong (in 2 in.), %	12–15	15–18	18	14–15
Red. of Area, %	25	32	—	35–40
Hardness (Brinell)	C30–34	C28–34	C26–32	C30–36
Impact Str (Charpy), ft-lb	—	—	15–20	11–15
Endurance Limit, 1000 psi				
Sheet (unnotched)	—	90	—	—
Bar (unnotched)	—	—	—	75–90
Bar (notched)	—	—	—	32[f]
Compr Yld Str, 1000 psi	—	120	—	—
Mod of Rigidity, psi	—	6×10^6	—	6.27×10^6
THERMAL TREATMENT				
Annealing Temp, F	—	900–1250	1250	1300
Stress Relieving Temp, F	—	<700 or at 1000	—	—
FABRICATING PROPERTIES				
Hot Working Temp Range, F	—	500–600	—	—
Forging Temp, F	—	—	1300–1700	1300–1750
Fusion Weldability[d]	No	No	Marginable	Questionable
Formability (sheet, 78 F)[e]	Intermediate	Intermediate	Moderate	Bar only
CORROSION RESISTANCE	Superior resistance to nitric acid, moist chlorine, chlorine solutions, chlorinated organic compounds, and inorganic chloride solutions. Excellent resistance to corrosive attack by sea water and most chloride salt solutions—unchallenged by other structural metals. Resists impingement, pitting attack			
AVAILABLE FORMS	Sheet, strip, plate, wire, bar, extrusions	Sheet, strip, plate	Sheet, plate, billet, bar, wire	Billets, bar, forgings, plate, wire
USES	Military aircraft parts requiring corrosion resistance and high strength-to-weight ratio up to 800 F. Naval and marine applications; chemical, pharmaceutical and food processing and handling equipment; marine diesel engine mufflers; springs (high proportional limit and low modulus of elasticity), rivets, bolts, nuts, screws and fittings; ordnance and sporting equipment; orthopedic and orthodontic equipment			

[a] Annealed condition unless otherwise stated.
[d] Some users report difficulty in producing welds without porosity; others do not.
[e] All titanium sheet is formed with considerably less difficulty at elevated temperatures. Forming can be accomplished at temperatures in the 500 to 1000 F range with no need for postforming surface treatment, provided time at temperature is short.
[f] $k = 3.9$.

Zinc Alloys

Type →	Commercial Rolled Zinc (deep drawing)	Commercial Rolled Zinc	Commercial Rolled Zinc	Copper Hardened Rolled Zinc Alloy	Rolled Zinc Alloy
COMPOSITION, %	Pb 0.10 max, Zn bal	Pb 0.05–0.10, Cd 0.05–0.08, Zn bal	Pb 0.25–0.50, Cd 0.25–0.45, Zn bal	Cu 0.85–1.25, Zn bal	Cu 0.85–1.25, Mg 0.006–0.016, Zn bal
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.258	0.258	0.258	0.259	0.259
Melting Point, F	786	786	786	792	792
Ther Cond (64 F), Btu/hr/sq ft/°F/ft	62.2	62.2	—	—	60.5
Coef of Ther Exp, per °F					
With Grain	18.1×10^{-6}	18.1×10^{-6}	18.8×10^{-6}	—	19.3×10^{-6}
Across Grain	12.8×10^{-6}	12.8×10^{-6}	13.0×10^{-6}	—	11.7×10^{-6}
Spec Ht (68–212 F), Btu/lb/°F	0.094	0.094	0.094	0.0957	0.0957
Elec Res (68 F), microhm-cm					
Hot Rolled	6.06	—	—	6.22	6.31
Cold Rolled	6.10	—	—	—	—
MECHANICAL PROPERTIES					
Ten Str, 1000 psi[a]					
Hot Rolled	19.5, 23	21, 25	23, 29	24, 30	29, 40
Cold Rolled	21, 27	22, 29	25, 31	31, 40	36, 46
Elong (in 2 in.), %[a]					
Hot Rolled	65, 50	52, 30	50, 32	50, 35	20, 10
Cold Rolled	50, 40	40, 30	45, 28	44, 30	25, 10
Hardness (Brinell)					
Hot Rolled	38	43	47	52	61
Cold Rolled	—	—	—	60	80
Endurance Limit (hot rolled), 1000 psi	2.5	3.8	4.1	6.1	6.8
FABRICATING PROPERTIES					
Hot Working Temp Range, F	248–527	248–527	248–437	447–572	447–572
Melting Range, F	887–977	887–977	887–977	887–977	887–977
Ingot Casting Range, F	815–905	815–905	815–905	815–905	815–905
Annealing Temp, F	—	—	221	347	347
Machinability	Good	Good	Good	Good	Good
Joining					
Torch Welding	Poor to fair	Poor to fair	Poor to fair	Poor to fair	Poor to fair
Single Impulse Resistance Welding	Poor	Poor	Poor	Poor	Poor
Multiple Impulse Resistance Welding	Fair to good	Fair to good	Fair to good	Fair to good	Fair to good
Soldering	Good	Good	Good	Good	Good
Common Processes	Drawing, bending, roll forming				
	Spinning, swaging, impact extrusion		Swaging, impact extrusion	Spinning, swaging	
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion (penetration in in. per yr is 0.000064 in Palmerton, Pa., and 0.00028 in New York City); also hot soapy water, printing inks, trichloroethylene, carbon tetrachloride, dry illuminating gas, and moisture- and acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water, petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water				
AVAILABLE FORMS	Rolled strip and sheet; extruded rod and shapes; drawn rod and wire				
USES	Drawn battery cans, eyelets, grommets, laundry tags, address plates, flashing		Soldered battery cans, photoengravers' and lithographers' sheets	Weatherstrip, nameplates, ferrules. Drawn, formed or spun parts requiring stiffness	Corrugated roofing, flat, drawn or moderately formed parts requiring maximum stiffness
	Drawn, formed or spun parts not requiring stiffness	Drawn, formed or spun parts requiring some rigidity			

[a]Two values represent properties parallel to grain and perpendicular to grain, in that order.

Cast Zinc Alloys

Type →	Alloy XXIII[a]	Alloy XXV[a]	Slush Casting Alloy[b]	Slush Casting Alloy (unbreakable metal)[b]
COMPOSITION, %	Al 3.5–4.3, Mg 0.03–0.08, Zn[c] bal	Al 3.5–4.3, Cu 0.75–1.25, Mg 0.03–0.08, Zn[c] bal	Al 4.5–5.0, Cu 0.2–0.3, Zn[c] bal	Al 5.25–5.75, Zn[c] bal
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.24	0.24	—	—
Melting Point, F	728	727	734	743
Ther Cond (158–284 F), Btu/hr/sq ft/°F/ft	65.3	62.9	—	—
Coef of Ther Exp (68–212 F), per °F	15.2×10^{-6}	15.2×10^{-6}	—	—
Spec Ht (68–212 F), Btu/lb/°F	0.10	0.10	—	—
Elec Res (68 F), microhm-cm	6.37	6.54	—	—
MECHANICAL PROPERTIES[d]				
Ten Str, 1000 psi				
Die Cast	41	47.6	—	—
Chill Cast	—	—	28.0	25.0
Elong (in 2 in.), %				
Die Cast	10	7	—	—
Chill Cast	—	—	—	1
Hardness (Brinell, die cast)	82	91	—	—
Impact Str (Charpy), ft-lb				
Die Cast	43	48	—	—
Chill Cast	—	—	3	1
Endurance Limit (10^8 cycles, die cast), 1000 psi	6.9	8.2	—	—
Compr Yld Str (die cast), 1000 psi	60	87	—	—
Shear Str (die cast), 1000 psi	31	38	—	—
FABRICATING PROPERTIES				
Melting Temp Range, F	728–932	727–932	—	—
Die Casting Temp Range, F	740–800	740–800	—	—
Solidification Shrinkage, %	1.17	1.17	—	—
Machinability	Good	Good	Good	Good
Joining				
Torch Welding	Poor to fair	Poor to fair	—	—
Single Impulse Resistance Welding	Poor	Poor	—	—
Multiple Impulse Resistance Welding	Fair to good	Fair to good	—	—
Soldering	Poor[e]	Poor[e]	—	—
Common Fabrication Processes	Welding, soldering, machining, riveting, spinning, cold swaging		Welding, soldering, machining	
CORROSION RESISTANCE	Excellent resistance to both metropolitan and rural atmospheric corrosion[f]; also hot soapy-water, printing inks, trichloroethylene, carbon tetrachloride, dry illuminating gas, and moisture- and acid-free hydrocarbons. Fair resistance to pure ethyl and methyl alcohols, glycerine, water and petroleum products. Poor resistance to steam, spray insecticides, animal oils, strong acids and bases, and mixtures of glycerine or alcohol and water			
USES	Automotive parts, household utensils, office equipment, building hardware, padlocks, toys, novelties, drop hammer dies (XXV)		Slush and permanent mold castings, principally for lighting fixtures	

[a]ASTM B86-53T.
[b]Because of their limited use, few data are available on these alloys.
[c]Special high grade zinc is required.
[d]Based on a ¼-in. section for die cast alloys; a ½-in. section for chill cast alloys.
[e]Cadmium-zinc and lead-tin solders diffuse into the casting, promoting subsurface attack. Castings must be nickel plated to be joined by lead-tin solders.
[f]Penetration in in. per yr in Palmerton, Pa., and New York City, respectively, is 0.78×10^{-4} and 2.2×10^{-4} for XXIII, and 0.63×10^{-4} and 2.8×10^{-4} for XXV.

LITHIUM: SELECT MATERIAL OF THE SPACE AGE

PRODUCT	PROPERTIES	APPLICATIONS
Lithium Metal **Li** **Purity:** **Li content 99.9%** **Lithium Metal** **(Low Sodium Content)** **0.005% Na Max.**	Atomic weight: 6.940. Color: silver-white. Density: 0.534 gm/cm³ at 20°C. Melting point: 180.5°C., 356.9°F. Boiling point: 1317°C., 2403°F. Hardness, Mohs' scale: 0.6. Vapor pressure: nil at 20°C., 14mm. at 900°C., 760 mm. at 1317°C. Heat of fusion: 103 cal/gm. Heat of vaporization: 4680 cal/gm. at 1317°C. Specific heat: 0.849 cal/gm/°C. at 25°C., 0.991 cal/gm/°C. at 180°C. (c), 1.047 cal/gm/°C. at 180°C. (l).	**Metallurgy**: Custom, light weight alloys of aluminum-lithium, magnesium-lithium, and magnesium - lithium - aluminum. Self - fluxing brazing alloys of lithium-silver and lithium-silver-copper. Deoxidizer, desulfurizer and degasifier in aluminum die castings, copper, copper-base, bronze and bearing alloys, precious metals (gold). Brazing flux for titanium and zirconium. **Nucleonics**: Fusion reactions. Heat transfer agent.
Lithium Metal Cartridges	Form: Lithium metal rod hermetically-sealed in deep drawn copper tubing by "Compression-Spin" process. 2.25 (0.005#), 4.50 (0.010#), & 9.0 (0.020#) gram charges, plus 108.0 gram copper cup (0.238#).	**Metallurgy**: Deoxidizer and general purifying agent for copper-base alloys. Production of high-conductivity copper castings.
Lithium Hydride **LiH**	Purity: The LiH assay, based on the hydrogen yield on reaction with H_2O, ranges from 93% to 98% depending on particle size. Molecular weight: 7.948. Color and form: gray-white to blue; translucent, crystalline mass; brittle. Density: 0.78 gm/cm³ at 20°C. Decomposition pressure: nil at 25°C., 0.7mm. at 500°C., 760 mm. at approx. 850°C. Melting point: 684°C. Specific heat: 1.03 cal/gm/°C. at 20°C. Heat of formation: -21.34.kcal/mole at 25°C. Solubility: quite insoluble in nonreactive solvents. Trace solubility reported in polar organic solvents, such as ether.	**Metallurgy**: Cited as a desulfurizing agent for iron and steel. **High Energy Fuels**: Starting material for the manufacture of decaborane (B_{10} H_{14}). **Chemical Manufacture**: Manufacture of lithium aluminum hydride and lithium borohydride. Pressurizing Fuel Tanks. **Nuclear Energy**: Radiation shielding against thermal neutrons. **Hydrogen Generation**: One lb. LiH reacts to generate approx. 45 cu. ft. of hydrogen.
Lithium Chloride **LiCl** **Grade: Technical, Anhydrous salt and 40% solution**	Molecular weight: 42.40. Color and form: white, hygroscopic, granular powder. Density: 2.068 gm/cm³ at 25°C. Melting point: 608°C. Boiling point: 1382°C. Specific heat: 0.288 cal/gm/°C. at 25°C. Heat of formation: -97.70 kcal/mole at 25°C. Heat of solution: -8.49 kcal/mole at 18°C. (200 moles H_2O/mole LiCl). Solubility: Moderately soluble in organic solvents such as alcohols, aldehydes, ketones, esters, pyridine, ethylenediamine, etc. Solubility in water: 40.8 wt. % @ 0°C., 45.4 wt. % @ 20°C., 56.3 wt. % @ 100°C.	**Metallurgy**: Flux component for brazing Al, Mg, Zr, Ti and their alloys. Electrolytic preparation of lithium and other metals. Component of salt bath for heat treating. **Atomic Energy**: Removel of fission products. **Dry Cells**: Used in the aqueous electrolyte which functions at temperatures as low as -60°F. **Aviation**: Preparation of de-icing solutions for parked aircraft in Arctic areas.
Lithium Fluoride **LiF** **Grade: Technical**	Molecular weight: 25.94. Color and form: white powder. Density: 2.639 gm/cm³ at 25°C. Melting point: 848°C. Boiling point: 1681°C. Specific heat: 0.386 cal/gm/°C. at 25°C. Heat of formation: -146.3 kcal/mole at 25°C. Solubility in water: 0.133 wt. % LiF at 25°C.	**Welding**: Used as a component of brazing fluxes and welding rod coatings. Its great affinity for aluminum and magnesium oxides, together with its high fluxing power, has made it a required ingredient. **Glass**: Fluxing agent in corrosion-resistant glass linings and low melting glasses for coating light metals.
Lithium Nitrate **$LiNO_3$** **Grade: Technical**	Molecular weight: 68.95. Li_2O content: 21.7%. Color and form: white, hygroscopic, crystalline powder. Density: 2.366 gm/cm³ at 20°C. Melting point: 251.4°C. Decomposition temperature: 600°C. Specific heat: 0.387 cal/gm/°C. at 210°C. Heat of formation: -115.279 kcal/mole at 25°C. Heat of solution: -0.333 kcal/mole at 18°C. (200 moles H_2O/mole $LiNO_3$). Solubility in water: 43 wt. % $LiNO_3$ at 20°C.	**Metallurgy**: Salt baths. Phosphate coating, of metals; lowered acidity and increased rate of reaction without affecting color or structure of coating. **High Energy Fuels**: Oxidizing agent for use in solid propellant combinations for rockets. **Nucleonics**: Heat exchange media. **Pyrotechnics**: Used in signal flares and fireworks.
Lithium Perchlorate **$LiClO_4$** **Grade: Technical**	Molecular weight: 106.40. Color and form: white, crystalline powder. Density: 2.43 gm/cm³ at 25°C. Melting point: 248°C. Decomposition starts at about 400°C. and becomes rapid at about 430°C., forming LiCl and oxygen. High content of available oxygen (60% by weight). Heat of formation: -91.8 kcal/mole at 25°C. Solubility in water: 29.9 wt. % $LiClO_4$ at 0°C., 37.5 wt. % $LiClO_4$ at 25°C, 71.5 wt. % $LiClO_4$ at 100°C.	**Oxidizing Agent**: Contains 60 wt. % available oxygen (as compared to 46 wt. % for $KClO_4$ and 25 wt. % for NH_4ClO_4). $LiClO_4$ contains more oxygen per unit volume than liquid oxygen.

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Polyethylene Resins. Phillips Chemical Co., Plastics Sales Div., 14 pp, illus. Shows hundreds of products made of polyethylene. Information on coloring, fabrication, heat and chemical resistance, and strength. **144**

Resins for Shell Molding. Plastics Engineering Co., 18 pp, illus. Description of resins developed for manufacturing shell molds. **145**

Teflon Products. Raybestos-Manhattan, Inc., Plastic Products Div., 8 pp. Typical applications, properties and sizes of Teflon and Raylon (reprocessed Teflon) sheets, tapes, and molded and extruded rods and tubes. **146**

Polyester Resins. Reichhold Chemicals, Inc., 12 pp, illus. Information on polyester resins for laminating, molding, casting, encapsulating and surfacing applications. **147**

Organisols, Plastisols. Reynolds Chemical Products Co., Div. of Stubnitz-Greene Corp., 11 pp. Corrosion resistance and properties of plastisols, organisols, lacquers, and natural and synthetic latex compounds for coating plating racks, bottles, rope and wire. **148**

Molded, Laminated Plastics. Richardson Co., 12 pp, illus. Shows facilities for producing molded and laminated plastics parts, including timing gears, camera viewers, printed circuits, bearings, sheets, rods and tubes. **149**

Reinforced Teflon Parts. Rogers Corp., 10 pp. Physical and electrical properties, wear, chemical and heat resistance, and uses for reinforced Teflon back-up rings, sheets, rods and tubes. **150**

Acrylic Molding Compound. Rohm & Haas Co., 8 pp, illus., No. PL-363. Physical properties, chemical resistance and uses of a modified acrylic for injection molding and extrusion. **151**

Vulcanized Fibre. Spaulding Fibre Co., Inc., 4 pp, illus. Fabricating data and uses of the company's line of vulcanized fibre products furnished in sheets, tubes and fabricated parts. **152**

Laminated Plastics. Synthane Corp., 28 pp, illus., No. S-358-75. Chemical resistance, mechanical, electrical and physical properties, uses, dimensional data, and design information for 36 grades of asbestos, paper and glass-base laminated plastics. **153**

Copper-Clad Laminates. Taylor Fibre Co. 4 pp, illus., No. 8-1. Physical, mechanical and electrical properties, dimensional data and availability of copper-clad plastics laminates for electronic printed circuits. **154**

Synthetic Rubbers. Texas-U. S. Chemical Co., 260 Madison Ave., New York 16. Specifications, physical and chemical properties, and test data for butadiene-styrene rubbers. Write on company letterhead directly to Texas-U. S. Chemical Co.

Butyl Rubber. Thiokol Chemical Corp., illus., Nos. 100-4 and 100-4B. Shows the effect of dimethylol phenol curing agents on compression set, heat resistance and physical properties of butyl rubber compounds. **155**

Plastics Resins. Bakelite Co., Div. of Union Carbide Corp., 12 pp, illus. Strength, chemical, heat and moisture resistance, electrical properties and uses of phenolic, vinyl, styrene, epoxy and polyethylene resins. **156**

Rubber Compounds. Colonial Rubber Co., Div. of U. S. Stoneware Co., 16 pp, illus. Properties and uses of the company's line of synthetic and "Silicol" silicone rubber compounds. **157**

Plastics Laminates. Westinghouse Electric Corp., Micarta Div., 8 pp, illus., No. B-6577. Information on construction and properties of copper-clad plastics laminates for printed circuits. **158**

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PROPERTIES OF MATERIALS

Plastics and Rubber

	PAGE
Acrylics	142
Alkyds	143
Cellulosics	144
Diallyl Phthalate	147
Cast Epoxies	148
Fluorocarbons	149
Melamines	150
Polyamides (Nylons)	152
Phenolics	154
Cast Phenolics	157
Cast Allyls and Polyesters	158
Polyethylenes	159
Silicones	160
Polystyrenes and Polymethylstyrenes	161
Modified Polystyrenes	162
Ureas	163
Polyvinyl Chloride and Copolymers	164
Polyvinyl Alcohol, Butyral and Formal	165
Acetal, Polycarbinate and Polypropylene	166
Plastics Films	167
High Pressure Laminates (General Purpose)	170
High Pressure Laminates (Mechanical)	172
High Pressure Laminates (Electrical)	174
Rubber	176
Hard Rubber	178
Flexible Foams	179
Foamed-in-Place Foams	180
Prefoamed Foams	181
Advertisements	182
Suppliers' Literature	140

Acrylics

Type →		Cast Resin Sheets, Rods		Moldings		
		General Purpose Type I[a]	General Purpose Type II[a]	Grade 5[b]	Grade 6[b]	Grade 8[b]
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792...	1.18–1.19	1.18–1.19	1.18	1.18	1.19
Ther Cond, Btu/hr/sq ft/°F/ft	[c]	0.10–0.15	0.10–0.15	0.12	0.12	0.12
Coef of Ther Exp, 10^{-5} per °F	D696...	5	5	4	4	3
Spec Ht, Btu/lb/°F	.....	0.35	0.35	0.35	0.35	0.35
Refractive Index	D542...	1.485–1.500	1.485–1.495	1.489–1.493	1.489–1.493	1.489–1.493
Transmittance (luminous, 0.125 in.), %	D791...	91–92	91–92	>92	>92	>92
Haze, %	D672...	1–2	1–2	<3	<3	<3
Water Absorption (24 hr), %	D570...	0.3–0.4	0.2–0.4	0.4	0.4	0.3
Flammability (0.125 in.), ipm	D635...	0.5–2.5	0.5–2.5	0.9–1.2	0.9–1.2	0.9–1.2
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638...	3.5–4.5	4.0–5.0	3.5–4.5	4.0–5.0	4.0–5.0
Ten Str, 1000 psi	D638...	6–8	8–10	8–9.5	9–10	9–10.5
Elong (in 2 in.), %	D638...	2–7	2–7	3–5	3–5	3–5
Hardness (Rockwell)	D785...	M90–100	M96–102	M80–88	M84–95	M92–103
Impact Str (Izod notched), ft-lb/in.	D256...	0.5	0.4	0.3–0.5	0.3–0.4	0.3–0.4
Mod of Elast in Flex, 10^5 psi	D790...	3.5–4.5	4.0–5.0	3.5–4.5	4.0–5.0	4.0–5.0
Flex Str, 1000 psi	D790...	12–14	15–17	15	15–16	16
Compr Yld Str (0.1% offset), 1000 psi	D695...	10–12	12–14	14.5	15	17
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257...	$>10^{15}$	$>10^{15}$	$>10^{14}$	$>10^{14}$	$>10^{15}$
Dielec Str (short time), v/mil	D149...	450–500	450–500	400–500	400–500	400–500
Dielec Const						
60 Cycles	D150...	3.5–4.5	3.5–4.5	2.3–3.9	2.3–3.9	2.2–3.5
10^6 Cycles	D150...	2.7–3.2	2.7–3.2	2.3–2.9	2.3–2.9	2.2–2.7
Dissip Factor						
60 Cycles	D150...	0.05–0.06	0.05–0.06	—	—	—
10^6 Cycles	D150...	0.02–0.03	0.02–0.03	0.03	0.03	0.02–0.03
Arc Resistance, sec	.....	No track	No track	No track	No track	No track
FABRICATING PROPERTIES						
Bulk Factor		—	—	1.8–2.2	1.8–2.2	1.8–2.2
Injection Molding						
Pressure, 1000 psi		—	—	15–25	15–25	20–30
Temperature, F		—	—	350–425	375–450	400–475
Hot Forming Temp, F		250–320	280–340	—	—	—
Extruding Temp, F		—	—	350–400	375–425	400–450
HEAT RESISTANCE						
Max Rec Svc Temp, F		140–160	180–200	155	165	190
Heat Dist Temp, F		150–170	190–210	166	176–180	196–202
CHEMICAL RESISTANCE		Resist weak alkalis, acids and aliphatic hydrocarbons. Attacked by esters, ketones, aromatic hydrocarbons, chlorinated hydrocarbons and concentrated acids				
USES		Transparent aircraft enclosures, radio and television parts, lighting, drafting equipment, signs		Decorative and functional automotive parts, reflectors, protective goggle lenses, radio and television parts, household appliance parts		

[a]ASTM D702-46. [b]ASTM D788-48T. [c]Cenco-Fitch.

Alkyds

Type ➡		General Purpose	Electrical	High Strength
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792...	2.22–2.24	2.16–2.18	2.00–2.08
Ther Cond, Btu/hr/sq ft/°F/ft	.....	0.35–0.60	0.35–0.60	0.20–0.30
Coef of Ther Exp, per °F	D696...	$1–3 \times 10^{-5}$	$1–3 \times 10^{-5}$	$1–3 \times 10^{-6}$
Water Absorption (24 hr), %	D570...	0.08–0.10	0.04–0.06	0.07–0.10
Flammability, ipm	.....	Not self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi	D651...	3–4	3–4	6–10
Impact Strength (Izod notched), ft-lb/in.	D256...	0.30–0.35	0.30–0.35	8–12
Mod of Elast in Flexure, psi	D790...	$22–27 \times 10^5$	$22–27 \times 10^5$	$22–28 \times 10^5$
Flexural Strength, 1000 psi	D790...	7–10	7–10	14–17
Compressive Strength, 1000 psi	D690...	16–20	18–20	24–28
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257...	10^{14}	10^{14}	10^{14}
Dielectric Strength (step by step), v/mil	D149...	300–350	300–350	300–350
Dielectric Constant				
60 Cycles	D150...	6.0–6.5	6.0–6.5	5.2–6.0
10^6 Cycles	D150...	4.8–5.0	4.2–4.5	4.0–4.5
Dissipation Factor				
60 Cycles	D150...	0.050–0.060	0.035–0.040	0.02–0.03
10^6 Cycles	D150...	0.016–0.018	0.014–0.015	0.017–0.022
FABRICATING PROPERTIES				
Bulk Factor	D954...	1.95–2.15	1.85–2.05	9–11
Compression Molding				
Pressure, 1000 psi	.....	1.0–1.5	1.0–1.5	1.5–2.0
Temperature, F	.....	270–330	270–330	270–330
HEAT RESISTANCE				
Max Rec Svc Temp (limited periods), F	.....	350	300	350
Heat Dist Temp (264 psi), F	D648...	350–400	350–400	>400
CHEMICAL RESISTANCE		Resistant to weak acids; attacked by alkalis; practically unattacked by organic liquids such as alcohols, hydrocarbons and fatty acids		
USES		Ignition parts, fuse blocks, switch and circuit breaker covers and bases, molded resistors and capacitors, television tuner segments		

Cellulose Acetate

Type →		Type I —Medium[a]	Type II—Hard[a]			Type III —Soft[a]
			H6	H4	H2	
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	1.27–1.34	1.29–1.34	1.28–1.34	1.27–1.34	1.27–1.34
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.10–0.19	0.10–0.19	0.10–0.19	0.10–0.19	0.10–0.19
Coef of Ther Exp, 10^{-5} per °F	D696	4.4–9.0	4.4–9.0	4.4–9.0	4.4–9.0	4.4–9.0
Refractive Index	D542	1.46–1.50	1.46–1.50	1.46–1.50	1.46–1.50	1.46–1.50
Spec Ht, Btu/lb/°F		0.3–0.42	0.3–0.42	0.3–0.42	0.3–0.42	0.3–0.42
Transmittance (luminous), %	D791	80–90	75–90	75–90	80–90	80–95
Haze, %	D672	3–10	4–15	4–15	4–10	3–8
Water Absorption (24 hr), %	D570	2.2–5.7	2.0–3.5	1.9–3.6	2.2–5.3	2.3–6.5
Flammability, ipm	D635	0.5–2.0	0.5–2.0	0.5–2.0	0.5–2.0	—
MECHANICAL PROPERTIES						
Ten Str, 1000 psi	D638	2.7–6.5	6–8.5	5.4–7.6	4.6–6.7	1.9–4.7
Elong (in 2 in.), %	D638	18–47	6–31	12–35	17–40	32–50
Hardness (Rockwell)	D785	R72–115	R112–123	R106–121	R101–119	R49–103
Impact Str (Izod notched), ft-lb/in.	D256	1.1–4.0	0.4–1.9	0.6–2.3	0.7–2.7	2.0–5.2
Mod of Elast in Flex, 10^5 psi		1.1–3.5	2.6–4.0	2.3–3.4	1.9–3.3	0.9–2.5
Compr Str, 1000 psi	D695	14.5–25	25–36	22–33	19–28	13–20
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{10}–10^{13}	10^{10}–10^{13}	10^{10}–10^{13}	10^{10}–10^{13}	10^{10}–10^{13}
Dielec Str (short time), v/mil	D149	250–365	250–365	250–365	250–365	250–365
Dielec Const						
60 cycles	D150	3.5–7.5	3.5–7.5	3.5–7.5	3.5–7.5	3.5–7.5
10^6 Cycles	D150	3.2–7.0	3.2–7.0	3.2–7.0	3.2–7.0	3.2–7.0
Dissipation Factor						
60 Cycles	D150	0.03–0.38	0.03–0.38	0.03–0.38	0.03–0.08	0.03–0.08
10^6 Cycles	D150	0.03–0.33	0.03–0.33	0.03–0.33	0.03–0.33	0.03–0.33
FABRICATING PROPERTIES						
Bulk Factor		2.0–2.6	2.0–2.6	2.0–2.6	2.0–2.6	2.0–2.6
Compression Molding						
Pressure, 1000 psi		500–5000	500–5000	500–5000	500–5000	500–5000
Temperature, F		280–350	350–420	330–390	320–370	260–310
Injection Molding						
Pressure, 1000 psi		8–32	8–32	8–32	8–32	8–32
Temperature, F		355–440	420–490	410–480	390–460	335–395
Extruding Temp, F		355–400	420–450	405–455	390–420	335–365
HEAT RESISTANCE		As these are thermoplastic materials, they gradually become softer as the temperature rises. Maximum service temperature depends on such factors as formula, design of part, humidity and service conditions				
CHEMICAL RESISTANCE		Unattacked by water, salt water solutions, white gasoline, oleic acid, 5% acetic acid and dilute sulfuric acid. Decomposed by 30% sulfuric, 10% nitric and 10% hydrochloric acids; sodium hydroxide; and 10% ammonium hydroxide. Dissolved by acetone and ethyl acetate				
USES		Automotive and radio knobs, tool handles, business machine keys. Electrical items such as fluorescent lamp supports, coil spools and contact bases. Toys and novelties, sunglass goggles and frames, spectacle frames, buttons and tags				

[a]ASTM D706-55T.

Cellulose Acetate Butyrate and Cellulose Propionate

Type →	ASTM	Cellulose Acetate Butyrate			Cellulose Propionate[b]
		Type I[a] (Medium)	Type II[a] (Hard)	Type III[a] (Soft)	
PHYSICAL PROPERTIES					
Specific Gravity	D792	1.16-1.24	1.19-1.25	1.15-1.22	1.18-1.24
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.10–0.19	0.10–0.19	0.10–0.19	0.10–0.19
Coef of Ther Exp (max), per °F	D696	6-9 x 10^{-5}	6-9 x 10^{-5}	6-9 x 10^{-5}	7-9 x 10^{-5}
Refractive Index	D542	1.46-1.49	1.46-1.49	1.46-1.49	1.46-1.48
Spec Ht, Btu/lb/°F		0.3-0.4	0.3-0.4	0.3-0.4	0.3-0.4
Transmittance (luminous), %	D791	80-90	75-90	85-95	80-90
Haze, %	D672	3-10	5-15	3-8	5-10
Water Absorption (24 hr), %	D570	1.3-2.1	1.5-2.2	1.1-2.1	1.2-2.0
Flammability, ipm[c]	D635	0.5-1.5	0.5-1.5	0.5-1.5	1.0-1.5
MECHANICAL PROPERTIES					
Ten Str, 1000 psi	D638	2.9-5.7	5.0-6.8	1.9-3.8	1.5-7.5
Elong, %		47-66	38-54	60-74	50-60
Hardness (Rockwell)		R79-112	R108-114	R59-95	R20-120
Impact Str (Izod notched), ft-lb/in.	D256	1.0-4.3	0.6-2.4	2.5-5.4	0.8-11.0
Mod of Elast in Flex, psi		0.93–1.7 x 10^5	1.5–2.0 x 10^5	0.74–1.3 x 10^5	1.6–3.3 x 10^5
Flex Str, 1000 psi		No break	No break	No break	No break
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10^{10}-10^{12}	10^{10}-10^{12}	10^{10}-10^{12}	10^{12}-10^{15}
Dielec Str (short time), v/mil	D149	250-400	250-400	250-400	300-450
Dielec Const					
60 Cycles	D150	3.5-6.4	3.5-6.4	3.5-6.4	—
10^6 Cycles	D150	3.2-6.2	3.2-6.2	3.2-6.2	3.4-3.6
Dissip Factor					
60 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	—
10^6 Cycles	D150	0.01-0.04	0.01-0.04	0.01-0.04	0.02-0.03
FABRICATING PROPERTIES					
Bulk Factor		2.0-2.4	2.0-2.4	2.0-2.4	1.6-2.0
Compression Molding					
Pressure, 1000 psi		0.5-5	0.5-5	0.5-5	—
Temperature, F		285-340	320-390	265-305	—
Injection Molding					
Pressure, 1000 psi		8-32	8-32	8-32	8-32
Temperature, F		355-440	390-480	335-395	310-480
Mold Shrinkage, in./in.		0.001-0.008	0.001-0.009	0.001-0.006	0.002-0.006
HEAT RESISTANCE					
Heat Dist Temp, F					
66 Psi	D648	156-197	188-233	139-164	130-200
264 Psi	D648	130-172	158-210	121-137	—
CHEMICAL RESISTANCE		Unaffected by 30% sulfuric, 5% acetic, 10% hydrochloric and oleic acids; discolored by 10% nitric acid. Unaffected by 1% sodium hydroxide and 2% sodium carbonate; slightly softened by 10% sodium hydroxide and discolored by 10% ammonium hydroxide. Unaffected by white gasoline, but swollen or dissolved by ethyl alcohol, acetone, ethyl acetate, ethylene dichloride, carbon tetrachloride and toluene. Unaffected by water, salt water and 3% hydrogen peroxide			
USES		Telephone handsets, steering wheels, automobile white-wall disks, film spools, irrigation tubing, radio housings. Electrical items such as fluorescent light supports, coil spools and contact bases.			Pen and pencil parts. Other uses similar to those of butyrate

[a] ASTM D707-55T.
[b] Values given are for compounds having different plasticizer contents.
[c] Self-extinguishing cellulose acetate butyrate compounds are available.

Cellulose Nitrate and Ethyl Cellulose

Type →		Cellulose Nitrate Sheet	Ethyl Cellulose Moldings		
			General Purpose	High Impact	
				A	B
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792	1.35-1.40	1.10-1.16	1.10-1.16	1.10-1.16
Ther Cond, Btu/hr/sq ft/°F/ft	Cenco-Fitch	0.133	0.092-0.167	0.092-0.167	0.092-0.167
Coef of Ther Exp, 10^{-5} per °F	D696	4.4–6.6	5.5–11	5.5–11	5.5–11
Refractive Index	D542	1.49-1.51	1.47	1.47	1.47
Transmittance (luminous), %	D791	89-92[a]	—	—	—
Haze, %	D672	2.0-4.0[a]	—	—	—
Water Absorption (24 hr), %	D570	1.0-2.0	1.2-2.0	0.8-2.0	1.0-2.0
Flammability (>0.050 in.), ipm	D635	[b]	0.5-1.5	0.5-1.5	0.5-1.5
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638	1.9-2.2	0.5-3.5	1.0-3.0	1.0-3.0
Ten Str, 1000 psi	D638	7-8	3-7	4-6.5	3-5
Strain at Fracture, %	D638	40-50	—	—	—
Hardness (Rockwell)	D785	R95-115	R80-120	R80-90	R70-80
Impact Str (Izod notched), ft-lb/in.	D758	5-7	1.7-6.0	3.5-6.0	4.0-7.0
Mod of Elast in Flex, 10^5 psi	D790	2.3-2.5	—	—	—
Flex Str, 1000 psi	D790	9-11[c]	4-10	6	4
Compr Str, 1000 psi	D695	22-35	—	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257	10-15 x 10^{10}	10^{12}-10^{14}	10^{12}-10^{14}	10^{12}-10^{14}
Dielec Str (short time), v/mil	D149	300-600	350-500	350-500	350-500
Dielec Const					
60 Cycles	D150	7.0-7.5	—	—	—
10^6 Cycles	D150	6.4	2.8-3.5	2.8-3.3	3.0-3.6
Dissip Factor					
60 Cycles	D150	0.09-0.12	—	—	—
10^6 Cycles	D150	0.06-0.09	0.010-0.060	0.010-0.030	0.018-0.035
FABRICATING PROPERTIES					
Bulk Factor		—	1.8-2.4	1.8-2.4	1.8-2.4
Compression Molding					
Pressure, 1000 psi		—	0.5-5	0.5-5	0.5-5
Temperature, F		—	250-390	250-390	250-390
Injection Molding					
Pressure, 1000 psi		—	6-32	8-32	8-32
Temperature, F		—	350-500	350-500	350-500
Hot Forming Temperature, F		135-250	—	—	—
Extruding Temperature, F		180-200	300-450	350-450	350-450
HEAT RESISTANCE					
Max Rec Svc Temp, F		120-140	—	—	—
Heat Dist Temp, F					
66 Psi		200-220	—	—	—
264 Psi		140-160	120-160	130-145	125-140
CHEMICAL RESISTANCE		Resistant to 30% sulfuric acid, carbon tetrachloride, 10% sodium chloride, 10% nitric acid, 10% hydrochloric acid, 5% acetic acid, 2% sodium tetrachloride, distilled water, aliphatic and aromatic hydrocarbons, and < 1% sodium hydroxide. Soluble in ketones, esters, lower alcohols and glycol ethers. Attacked by concentrated sodium hydroxide, ethylene dichloride and 50% ethanol		Unaffected by 3 sulfuric, 5 acetic and 10% hydrochloric acids; 10% sodium hydroxide, 2% sodium carbonate and water. Slightly affected by 30 sulfuric and 10% nitric acids; and 10% ammonium hydroxide. Attacked by 95% ethyl alcohol, acetone, toluene and gasoline	
USES		Fountain pens, spectacle frames, drawing instruments, ping-pong and billiard balls		Radio housings, toothbrushes, pen and pencil barrels, tool handles	

[a] 1/8-in. sheet containing no color.

[b] Cellulose nitrate under 0.050 in. thick burns very rapidly (D568).

[c] No break; specimen failed by slipping through supports.

Diallyl Phthalate

Type →		Orlon-Filled	Dacron-Filled	Asbestos-Filled	Glass Fiber-Filled
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.31–1.34	1.40	1.65–1.70	1.55–1.59
Coef of Ther Exp, per °F	D696...	1.5 x 10^{-5}	2.0 x 10^{-5}	3.5 x 10^{-5}	2.2–2.6 x 10^{-5}
Water Abs (122 F, 48 hr), %	.....	0.2–0.5	0.2	0.4–0.5	0.12–0.2
Flammability (ignition time), sec	.....	68	84–90	70	400–450
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi[a]	D638...	6 x 10^5	—	17 x 10^5	—
Ten Str, psi	D638...	4500–6000	4600	4000–5500	5500–7000
Hardness (Rockwell)	D785...	M108	—	M107	M100
Impact Str (Izod notched), ft-lb/in	D256...	0.5–1.2	1.7–4.5	0.30–0.45	0.5–6.0
Flex Str, 1000 psi	D790...	10–10.5	9–11.5	8–10	10–12
Compr Str, 1000 psi	D695...	20–30	30	18–25	25
ELECTRICAL PROPERTIES					
Dielec Str, v/mil					
Short Time (dry)	D149...	366	376–390	378	382–430
Short Time (wet[b])	D149...	375	360–391	330	345–420
Step by Step (dry)	D149...	364	350–374	320–350	335–420
Step by Step (wet[b])	D149...	333	350–361	225–250	295–420
Dielec Breakdown, kv					
Short Time (dry)	.....	55–81.7	70–80	55–80	63–70
Short Time (wet[b])	.....	60–65	66–70	55	45–65
Step by Step (dry)	.....	55–60.5	60–65	38–70	60–65
Step by Step (wet[b])	.....	46–60	60	39–60	49.5–65
Dissip Factor[c]					
Dry	D150...	0.023, 0.015	0.006, 0.012	0.039, 0.040	0.004, 0.010
Wet[d]	D150...	0.026, 0.020	0.009, 0.017	0.042, 0.154	0.008, 0.015
Dielec Const[c]					
Dry	D150...	3.9, 3.3	3.8, 3.4	5.2, 4.5	4.5, 4.2
Wet[d]	D150...	4.1, 3.3	3.8, 3.6	4.8, 4.7	4.6, 4.4
Vol Res, megohm-cm[d]	D257...	60,000	100–25,000	6000	1000
Surface Res, megohms[d]	D257...	25,000	500–10,000	6000	500
Arc Resistance, sec	D495...	85–115	105–125	125–140	125
FABRICATING PROPERTIES					
Bulk Factor	D392...	3.5–5.2	5.2	1.9–2.4	1.9–4.0
Compression Molding					
Pressure, psi	.....	500–2000	500–2000	500–2000	500–2000
Temperature, F	.....	270–320	270–320	270–320	270–320
Transfer Molding					
Pressure, psi	.....	1000–5000	1000–5000	1000–5000	1000–5000
Temperature, F	.....	270–310	270–310	270–310	270–310
Mold Shrinkage, in./in.	.....	0.009	0.010	0.004–0.007	0.004
Post-Mold Shrinkage (480 hr, 257 F), in./in.	.....	0.001	0.0006	0.0005	0.0005–0.0007
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	300	300–370	350–450	400–450
Heat Dist Temp, F	D648...	240–266	270–290	300–350	300–350
CHEMICAL RESISTANCE		Unaffected by weak acids and alkalis and organic solvents. Slightly affected by strong acids and alkalis			

[a]Conditioned 48 hr at 122 F.
[b]Tested after 48-hr immersion in water at 122 F.
[c]Values given for frequencies of 1 kc and 1 mc, in that order.
[d]Conditioned 30 days at 100% RH and 158 F.

Cast Epoxies

Type →		Epoxy	Polysulfide-Epoxy
PHYSICAL PROPERTIES	ASTM		
Specific Gravity	D638...	1.15–1.19	1.15–1.23
Ther Cond, Btu/hr/ sq ft/°F/ft	C177...	0.097–0.116	—
Coef of Ther Exp, per °F	D696...	2.66–5.00 x 10^{-5}	1.1–5.5 x 10^{-5}
Water Absorption (24 hr), %	D570...	0.05–0.12	0.25–0.50
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	D638...	4.5–5.4 x 10^5	0.01–3.5 x 10^5
Tensile Strength, 1000 psi	D638...	8.5–12	3–10
Elongation (in 2 in.),%	D638...	—	0–100
Hardness (Rockwell)	D785...	M80–105	—
Impact Strength (Izod notched), ft-lb/in	D256...	0.35–0.7	2–10
Flexural Strength, 1000 psi	D790...	14.5–18.5	1–18
Compressive Strength, 1000 psi	D695...	15.5–23.5	1–14
ELECTRICAL PROPERTIES			
Volume Resistivity, ohm-cm	D257...	>8 x 10^{12}	1.3–15 x 10^{12}
Dielectric Strength (short time), v/mil	D149...	400–500	235–400
Dielectric Constant			
60 Cycles	D150...	3.7–4.1	2.5–4.5
10^6 Cycles	D150...	3.4–3.8	3–6
Dissipation Factor			
60 Cycles	D150...	0.001–0.002	0.010–0.040
10^6 Cycles	D150...	0.020–0.026	0.018–0.090
Arc Resistance, sec	D495...	50–180	50–180
HEAT RESISTANCE			
Max Rec Svc Temp, F		300	250–300
Heat Dist Temp (264 psi), F		150–225	150–250
CHEMICAL RESISTANCE		Resistant to weak acids and some strong acids. Slightly affected by some strong alkalis. Practically unattacked by organic liquids such as alcohols and hydrocarbons	
USES		Tools and dies, potting and encapsulation of electrical components, preparation of precision castings. High strength laminates, structural adhesives, patching compounds	

Fluorocarbons

Type ➡		Polytrifluorochloro-ethylene	Polytetrafluoro-ethylene
PHYSICAL PROPERTIES	ASTM		
Specific Gravity	D792...	2.10–2.15	2.1–2.3
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.035–0.036	0.034
Coef of Ther Exp, per °F	D696...	3.88×10^{-5}	5.5×10^{-5}
Refractive Index	D542...	1.43	1.35
Specific Heat, Btu/lb/°F	.....	0.22	0.25
Transmittance (luminous), %	D791...	80–92	—
Water Absorption (24 hr), %	D570...	0.00	0.00
Flammability	.....	Nonflammable	Nonflammable
MECHANICAL PROPERTIES			
Mod of Elast in Compression, psi	D638...	1.8×10^5	$0.70–0.90 \times 10^5$
Mod of Elast in Tension, psi	D638...	$1.9–3.0 \times 10^5$	$0.38–0.65 \times 10^5$
Tensile Strength, 1000 psi	D638...	4.6–5.7	1.5–3.0
Elongation (in 2 in.), %	D638...	28–87	120–350
Hardness (Rockwell)	D785...	R110–115	J75–95
Abrasion Resistance, gm/cycle	[b]	0.0080	—
Impact Strength (Izod notched), ft-lb/in.	D256...	3.50–3.62	2.5–4.0
Mod of Elast in Flexure, psi	D747...	$2.0–2.5 \times 10^5$	0.6×10^5
Flexural Strength (0.1% offset), 1000 psi	D790...	—	1.6
Compressive Strength (0.1% offset), 1000 psi	D695...	2.0	0.7–1.8
ELECTRICAL PROPERTIES			
Volume Resistivity, ohm-cm	D257...	10^{18}	10^{19}
Dielectric Strength (short time), v/mil	D149...	530–600	400–500
Dielectric Constant			
60 Cycles	D150...	2.6–2.7	2.0
10^6 Cycles	D150...	2.30–2.37	2.0
Dissipation Factor			
60 Cycles	D150...	0.02	0.0002
10^6 Cycles	D150...	0.007–0.010	0.0002
Arc Resistance, sec	.....	>360	>200
FABRICATING PROPERTIES			
Injection Molding			
Pressure, 1000 psi	.....	5–30	—
Temperature, F	.....	420–620	—
Compression Molding			
Pressure, 1000 psi	.....	0.1–15	—
Temperature, F	.....	445–525	—
Bulk Factor	.....	2.5	—
Mold Shrinkage, in./in.	.....	0.005–0.010	—
HEAT RESISTANCE			
Max Rec Svc Temp, F	.....	380	500
Heat Dist Temp, F			
66 Psi	D648...	196–291	—
264 Psi	D648...	151–178	—
CHEMICAL RESISTANCE		Impervious to corrosive chemicals; highly resistant to most organic solvents. Swelling may occur with some highly halogenated and aromatic compounds	Inert to most chemicals and solvents with the exception of alkali metals. Halogenated solvents at high temperatures and pressure have some effect
USES		Chemical pipes, gaskets, pump parts, electrical cables, tank linings, connectors, coil forms, connector inserts, valve diaphragms, electrical insulation	Chemical pipes, valves and valve liners, gaskets and packings, pump bearings and impellers, electrical and electronic equipment, anti-adhesive coatings

[a] Cenco-Fitch.
[b] Federal Spec L-P-406A #1092.1.

Melamines

Filler and Type →		Alpha Cellulose—General Purpose	Mineral—Electrical	Fabric—Low to Intermediate Shock Resistant	Fabric—Intermediate Resistance
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.47–1.52	1.7–2.0	1.5	1.5
Ther Cond, Btu/hr/sq ft/°F/ft	.....	0.17–0.24	0.32–0.41	0.257	0.25–0.26
Coef of Ther Exp per °F	D696...	1.11–3.17 x 10^{-5}	1.06–2.50 x 10^{-5}	1.55 x 10^{-5}	1.55 x 10^{-5}
Transmittance (luminous), %	D570...	14.5	Opaque	Low	—
Water Absorption (24 hr), %	D570...	0.1–0.6	0.08–0.14	0.3–0.6	0.2–1.3
Flammability	.....	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638...	13–16 x 10^5	16–19.5 x 10^5	16 x 10^5	16 x 10^5
Ten Str, 1000 psi	D638...	7–10	5.5–7.0	8–9.5	5.7–9
Elong (in 2 in.), %	D638...	—	0.30–0.45	0.6–0.8	0.6
Hardness (Rockwell)	D785...	M118–124, E110	M110	M120	M115
Impact Str (Izod notched), ft-lb/in.	D256...	0.24–0.35	0.28–0.40	0.5–0.9	1.0–1.5
Mod of Elast in Flex, psi	D790...	15 x 10^5	16 x 10^5	18.5 x 10^5	19 x 10^5
Compr Str, 1000 psi	D695...	40–45	25–30	30–35	25–32
Flex Str, 1000 psi	D790...	10–16	8.7–11	12–15	13–17
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	10^{12}–10^{14}	10^{11}–10^{13}	10^9–10^{12}	—
Dielec Str (short time), v/mil	D149...	310–330	350–430	250–350	130–370
Dielec Const					
60 Cycles	D150...	8.4–9.4	6.4–10.2	7.6–8.6	10.5–15.5
10^6 Cycles	D150...	5.6–5.8	6.1–6.7	6.5–6.9	6.1–6.7
Dissip Factor					
60 Cycles	.....	0.05–0.08	0.07–0.17	0.07–0.11	0.10–0.32
10^6 Cycles	.....	0.03–0.04	0.04–0.05	0.036	0.050–0.065
Arc Resistance, sec	D495...	122–128	120–170	115–128	5–8
FABRICATING PROPERTIES					
Bulk Factor	D392...	2.1–3.1	2.1–2.5	5–10	5–10
Compression Molding					
Pressure, 1000 psi	.....	1.5–8	1–7	4–8	4–8
Temperature, F	.....	280–370	275–340	275–330	300–380
Transfer Molding					
Pressure, 1000 psi	.....	4–12	4–20	—	—
Temperature, F	.....	300–320	270–340	—	—
Mold Shrinkage, in./in.	.....	0.006–0.015	0.003–0.007	0.003–0.004	0.004–0.005
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	210	250–400	250	250
Heat Dist Temp (264 psi), F	D648...	350–410	265	310	375
CHEMICAL RESISTANCE		Resistant to weak acids, weak alkalis, organic solvents, greases and oils. Attacked by strong acids and strong alkalis			
USES		General purpose electrical and mechanical applications such as kitchenware, tableware, lighting fixtures, reflectors	Elevated temperature and electrical applications such as ignition parts, circuit breakers, terminal blocks, electronic parts	Applications requiring improved impact strength, such as insulation, circuit breakers, food trays, medical equipment	Applications requiring medium impact strength, such as nozzles, insulation

Melamines—concluded

Filler and Type →		Unfilled	Cellulose Electrical	Glass Fiber	Alpha Cellulose and Mineral
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.48	1.43–1.50	1.9–2.0	1.49
Ther Cond, Btu/hr/sq ft/°F/ft	.....	—	0.17–0.20	0.28	—
Coef of Ther Exp, per °F	D696...	—	1.11–2.78 x 10^{-5}	0.82 x 10^{-5}	—
Transmittance (luminous), %	.....	Good	Opaque	—	—
Water Absorption (24 hr), %	D570...	0.3–0.5	0.27–0.80	0.10–0.60	0.5
Flammability	D570...	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638...	—	10–11 x 10^5	—	—
Ten Str, 1000 psi	D638...	—	5–9	6–10	5
Elong (in 2 in.), %	D638...	—	0.6	—	—
Hardness (Rockwell)	D785...	—	M115–125	—	—
Impact Str (Izod notched), ft-lb/in.	D256...	—	0.27–0.36	4.0–12.0	0.30
Mod of Elast in Flex, psi	D790...	13 x 10^5	1.0–1.3 x 10^5	—	—
Compr Str, 1000 psi	D695...	40–45	25–33.6	26–32	—
Flex Str, 1000 psi	D790...	11–14	9–10	10–23	8
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	—	10^{12}–10^{13}	1–7 x 10^{11}	10^{12}
Dielec Str (short time), v/mil	D149...	—	350–400	250–300	375
Dielec Const					
60 Cycles	D150...	—	6.2–7.6	9.7–11.1	—
10^6 Cycles	D150...	—	4.7–7.0	6.9–7.2	6.4
Dissip Factor					
60 Cycles	.....	—	0.019–0.033	0.14–0.23	—
10^6 Cycles	.....	—	0.032–0.06	0.02–0.03	0.031
Arc Resistance, sec	D495...	100–145	95–135	180–186	125
FABRICATING PROPERTIES					
Bulk Factor	D392...	2.0	2.2–2.6	5–7	2.4
Compression Molding					
Pressure, 1000 psi	.....	2–5	1.5–3	2–8	2–5
Temperature, F	.....	300–340	290–360	280–340	280–350
Transfer Molding					
Pressure, 1000 psi	.....	—	6–20	8–20	2–10
Temperature, F	.....	—	300–330	290–310	285–350
Mold Shrinkage, in./in.	.....	0.011–0.012	0.006–0.008	0.001–0.004	0.006–0.007
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	210	250–280	300–400	275–325
Heat Dist Temp (264 psi), F	D648...	293–298	265	400	300
CHEMICAL RESISTANCE		Resistant to weak acids, weak alkalis, organic solvents, greases and oils. Attacked by strong acids and strong alkalis			
USES		Pearlescent buttons, moldings ornamental applications	General mechanical and electrical applications, particularly at elevated temperatures. Applications requiring improved holding power for metallic inserts such as electrical and electronic parts	Applications requiring high shock resistance, good electrical properties, and high resistance to burning. Switchgear, terminal strips, standoff insulators, coil forms	Primarily electrical applications requiring low after-shrinkage, good dimensional stability and excellent molding characteristics

Polyamides (Nylons)

Type ➡		66 Nylon			610 Nylon	
		General Purpose Injection Molding		Extrusion and Injection Molding	Extrusion and Injection Molding	
		0.2% Water	2.5% Water		0.2% Water	1.5% Water
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792...	1.14	—	1.14	1.09	—
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.14	—	0.142	0.12	—
Coef of Ther Exp, 10^{-5} per °F	D696...	5.5	—	5.5	5.5	—
Spec Ht, Btu/lb/°F	.....	0.3–0.5	—	0.4	0.3–0.5	—
Refractive Index	D542...	1.53	—	—	1.53	—
Water Absorption (24 hr), %	D570...	1.5	—	1.5	0.4	—
Flammability	D757...	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638...	4.1	2.1	4.0	2.8	1.6
Ten Str, 1000 psi	D638...	11.8	11.2	11.2–12.6	8.5	7.1
Elong (in 2 in.), %	D638...	60	300	100–200	85	320
Hardness (Rockwell)	D785...	M79, R118	M59, R108	R118	R111	—
Impact Str (Izod notched), ft-lb/in.	D256...	0.9	2.0	1.1–1.5	0.6	1.6
Mod of Elast in Flex, 10^5 psi	D790...	4.1	2.1	—	2.8	1.6
Flex Yld Str, 1000 psi	D790...	13.8	—	13.8	8	—
Compr Yld Str, 1000 psi	D695...	13	—	—	7.2	—
Compr Yld Str (1% def), 1000 psi	D695...	—	—	4.9	—	—
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257...	—	—	4.5×10^{13}	—	—
Dielec Str (short time), v/mil	D149...	385	—	385	470	—
Dielec Const						
60 Cycles	D150...	4.0	7.6	4.1	3.9	—
10^6 Cycles	D150...	3.6	3.6	3.4	—	—
Dissip Factor						
60 Cycles	D150...	0.01	0.09	0.014	—	—
10^6 Cycles	D150...	0.02	0.08	0.04	0.02	—
Arc Resistance, sec	D495...	—	—	—	—	—
FABRICATING PROPERTIES						
Bulk Factor	D392...	2.1	—	2.14	2.2	—
Injection Molding						
Pressure, 1000 psi	.....	10–20	—	—	10–20	—
Temperature, F	.....	520–650	—	—	450–600	—
Joining	.....	Can be cemented with aqueous phenol or various proprietary adhesives. Spin welding, extrusion lamination and other techniques can be used in special cases				
HEAT RESISTANCE						
Max Rec Svc Temp, F	.....	275–300	—	—	225	—
Heat Dist Temp, F						
66 Psi	D648...	—	—	360	—	—
264 Psi	D648...	—	—	150	—	—
CHEMICAL RESISTANCE		Inert to most organic chemicals such as esters, ketones, alcohols and hydrocarbons. Resist alkalis and salt solutions, but attacked by phenols, formic acid, mineral acid and strong oxidizing agents				
USES		Gears, bearings, automatic washing machine valves, rollers and slides, combs and brush backs, aerosol bottles, coil forms, and mechanical parts where lubrication is undesirable or difficult		Tubing, rods, pipe, sheeting, laminations	Jacketing for wire and cable; special molded parts	

[a]Cenco-Fitch.

Polyamides (Nylons)—concluded

Type →		6 Nylon		Soluble Resin (solution, injection, extrusion)	Glass Fiber–Filled
		General Purpose Injection Molding	Extrusion and Injection Molding		
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.13–1.14	1.14	1.12–1.13	1.33
Ther Cond, Btu/hr/sq ft/°F/ft	[a]	0.10–0.14	0.11–0.12	0.16	—
Coef of Ther Exp, 10^{-5} per °F	D696...	4.6–5.4	4.6–7.1	8.2	Very low
Spec Ht, Btu/lb/°F	.....	0.4	—	0.4	—
Refractive Index	D542...	—	—	—	—
Water Absorption (24 hr), %	D570...	1.6–2.0	2.1–3.3	2.0–5.5	0.2–1.2
Flammability	D757...	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638...	2.5–3.4	1.5–3.6	0.38	—
Ten Str, 1000 psi	D638...	10.2–12	10.2–11.3	3.8–7.4	12–20
Elong (in 2 in.), %	D638...	300	300	300–600	6.5–8.5
Hardness (Rockwell)	D785...	R105–118	R103–111	R45–83	M85–95
Impact Str (Izod notched), ft-lb/in.	D256...	1.2–3.0	1.5–3.5	>16	2.0
Mod of Elast in Flex, 10^5 psi	D790...	—	—	0.3–0.7	—
Flex Yld Str, 1000 psi	D790...	15.5	—	1–2	>25
Compr Yld Str, 1000 psi	D695...	11–12	—	—	—
Compr Yld Str (1% def), 1000 psi	D695...	7.1–9.7	6.7–8.8	0.8	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	10^{13}–10^{15}	10^{13}–10^{15}	5×10^{13}	$4.9–5.7 \times 10^{15}$
Dielec Str (short time), v/mil	D149...	420–485	440–500	420	487–520
Dielec Const					
60 Cycles	D150...	4.5–11.5	5.1–14.0	10.7	3.99–4.03
10^6 Cycles	D150...	3.6–4.3	3.5–4.5	4.5	3.37–3.45
Dissip Factor					
60^0 Cycles	D150...	0.03–0.07	0.06–0.10	0.19	0.0155–0.0210
10^6 Cycles	D150...	0.03–0.13	0.03–0.11	0.14	0.0171–0.0176
Arc Resistance, sec	D495...	—	—	—	147–149
FABRICATING PROPERTIES					
Bulk Factor	D392...	1.60–1.68	1.72–1.82	2.5	2.0
Compression Molding					
Pressure, 1000 psi	.....	—	—	1–2	—
Temperature, F	.....	—	—	325–380	—
Injection Molding					
Pressure, 1000 psi	.....	10–25	—	10–25	10–25
Temperature, F	.....	440–550	—	300–500	450–700
Extruding Temp, F	.....	450–550	430–550	500–550	—
Joining	.....	Nylon adhesive or aqueous phenol		[b]	—
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	225–250	200–250	140	300–400
Heat Dist Temp, F					
66 Psi	D648...	340	—	100	350
264 Psi	D648...	145	—	—	—
CHEMICAL RESISTANCE		Resists esters, ketones, alkalis, weak acids, alcohols and common solvents. Not resistant to conc mineral acids	Resists petroleum oils and greases, alkalis, esters, ketones, alcohols and common solvents. Not resistant to mineral acids	Resists ketones, alkalis and esters. Not resistant to alcohols, phenols, formic acid, and mineral acids	Attacked by strong acids. Fairly resistant to strong alkalis. Resists common solvents
USES		Bearings, gears, bushings, coil forms, brush backs, rod, tubing, tape	Abrasion resistant shielding on insulated wire and mechanical cable. Pipe, tubing	Jacketing for wire and cable, seals, packings, sheeting, adhesives, abrasion-resistant finishes	Gears, business machine parts, appliance handles, terminal blocks, meter housings

[a] Ceneo-Fitch.
[b] Can be bonded with 70-80 methanol-water as cement, or 10% solution of resin in methanol-water as solvent.

Phenolics

Type and Filler ➡		General—Woodflour and Flock	Shock—Paper, Flock or Pulp	High Shock—Chopped Fabric or Cord	Very High Shock—Glass Fiber
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.32–1.55	1.34–1.46	1.36–1.43	1.75–1.90
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.097–0.170	0.1–0.16	0.097–0.170	—
Coef of Ther Exp, 10^{-5} per °F	D696...	1.66–2.50	1.6–2.3	1.60–2.22	0.88
Spec Ht, Btu/lb/°F	D570...	0.35–0.40	—	0.30–0.35	0.28–0.32
Water Absorption (24 hr), %	D635...	0.3–0.8	0.4–1.5	0.4–1.75	0.1–1.0
Flammability	.....	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638...	8–13	8–12	9–14	30–33
Ten Str, 1000 psi	D638, D651...	6.5–8.5	5.0–8.5	5–9	5–10
Elong (in 2 in.), %	D638...	0.4–0.8	—	0.37–0.57	0.2
Hardness (Rockwell)	D785...	M108–120	—	M93–120	M95–100
Impact Str (Izod notched), ft-lb/in.	D256...	0.24–0.50	—	0.6–8.0	10–33
Mod of Elast in Flex, 10^5 psi	.....	8–12	—	9–13	—
Flex Str, 1000 psi	D570...	8.5–12	8.0–11.5	8–15	10–45
Compr Str, 1000 psi	D695...	22–36	24–35	15–30	17–30
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	10^9–10^{13}	1–50 x 10^{11}	>10^{10}	7–10 x 10^{12}
Dielec Str (short time), v/mil	D149...	200–425	250–350	200–350	200–370
Dielec Const					
60 Cycles	D150...	5.0–9.0	5.6–11.0	6.5–15.0	7.1–7.2
10^6 Cycles	D150...	4.0–7.0	4.5– 7.0	4.5– 7.0	4.6–6.6
Dissip Factor					
60 Cycles	D150...	0.05–0.30	0.08–0.35	0.08–0.45	0.02–0.03
10^6 Cycles	D150...	0.03–0.07	0.03–0.07	0.03–0.09	0.02
Arc Resistance, sec	D495...	5	5	5	60
FABRICATING PROPERTIES					
Bulk Factor	.....	2.1–4.4	2.3–5.7	3.0–18.0	6.1–6.3
Compression Molding					
Pressure, 1000 psi	.....	1.5–5.0	2–5	2–6.5	1–5
Temperature, F	.....	290–380	290–380	280–380	500–5000
Transfer Molding					
Pressure, 1000 psi	.....	2–10	2–10	2–12	—
Temperature, F	.....	275–340	275–340	275–340	—
Mold Shrinkage, in./in.	.....	0.005–0.008	0.004–0.009	0.002–0.009	0.0
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	300–350	300	250–275	350–450
Heat Dist Temp, F	D648...	260–340	290–340	250–340	600
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

Phenolics—continued

Type and Filler ➡		High Frequency—Mineral	Shock & Heat—Mineral, Flour and Yarn	Heat—Mineral	Chemical (no filler)
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.75–1.92	1.68–2.00	1.54–1.75	1.24–1.90
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.24–0.34	0.19–0.39	0.19–0.39	—
Coef of Ther Exp, 10^{-5} per °F	D696...	1.05–1.44	0.83–1.17	1.17	2.4
Spec Ht, Btu/lb/°F	D570...	0.28–0.32	0.28–0.32	0.28–0.32	—
Water Absorption (24 hr), %	D635...	0.01–0.07	0.1–0.5	0.2–0.5	0.15–0.60
Flammability	.....	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638...	30–50	15–25	10–20	7–15
Ten Str, 1000 psi	D638, D651...	5–7	4–9	4–6.5	4.5–7.5
Elong (in 2 in.), %	D638...	0.10–0.53	—	—	—
Hardness (Rockwell)	D785...	M100–110	M100–110	M98–115	M105–120
Impact Str (Izod notched), ft-lb/in.	D256...	0.30–0.38	0.27–3.50	0.24–0.40	0.2–0.6
Mod of Elast in Flex, 10^5 psi	.....	30–40	10–25	10–20	7–15
Flex Str, 1000 psi	D570...	8–12	7–15	3–10.5	7–12
Compr Str, 1000 psi	D695...	15–25	15–25	15–35	18–32
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	10^{13}	10^{10}–10^{12}	10^{11}–10^{12}	10^{1} –10^{12}
Dielec Str (short time), v/mil	D149...	300–375	100–250	150–350	225–275
Dielec Const					
60 Cycles	D150...	4.7–5.5	30–150	5.8–40.0	9–19
10^6 Cycles	D150...	4.4–5.1	5–7	4.8– 8.0	5.5–7.0
Dissip Factor					
60 Cycles	D150...	0.01–0.07	0.25–0.50	0.10–0.35	0.15–0.25
10^6 Cycles	D150...	0.005–0.02	0.10–0.50	0.04–0.15	0.04–0.09
Arc Resistance, sec	D495...	16	6	5–120	—
FABRICATING PROPERTIES					
Bulk Factor	.....	2.1–2.7	3–14	2.0–2.8	1.9–3.0
Compression Molding					
Pressure, 1000 psi	.....	2.0–5.5	2–6	2–6	2–6
Temperature, F	.....	300–350	290–380	290–380	300–360
Transfer Molding					
Pressure, 1000 psi	.....	2–10	2–12	2–9	2–10
Temperature, F	.....	275–325	275–325	275–325	275–340
Mold Shrinkage, in./in.	.....	0.003	0.0005–0.005	0.002–0.006	0.002–0.01
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	250–300	350–400	375–425	300–425
Heat Dist Temp, F	D648...	230–325	290–375	350–400	300–350
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

continued

Phenolics—concluded

Type and Filler →		Arc Resistant—Mineral	Rubber Phenolic—Woodflour or Flock	Rubber Phenolic—Chopped Fabric	Rubber Phenolic—Asbestos
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.8–3.0	1.24–1.35	1.30–1.35	1.60–1.65
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.24–0.34	0.12	0.05	0.04
Coef of Ther Exp, 10^{-5} per °F	D696...	—	0.83–2.20	1.7	2.2
Spec Ht, Btu/lb/°F	D570...	0.28–0.32	0.33	—	—
Water Absorption (24 hr), %	D635...	0.2	0.5–2.0	0.5–2.0	0.10–0.50
Flammability	.....	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D638...	—	4–6	3.5–6	5–9
Ten Str, 1000 psi	D638, D651...	6	4.5–9	3.5	4
Elong (in 2 in.), %	D638...	—	0.75–2.25	—	—
Hardness (Rockwell)	D785...	—	M40–90	M57	M50
Impact Str (Izod notched), ft-lb/in.	D256...	0.32	0.34–1.0	2.0–2.3	0.3–0.4
Mod of Elast in Flex, 10^5 psi	.....	—	4–6	3.5	5.0
Flex Str, 1000 psi	D570...	10	7–12	7	7
Compr Str, 1000 psi	D695...	20	12–20	10–15	10–20
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	6×10^{12}	10^6–10^{11}	10^{11}	10^{11}
Dielec Str (short time), v/mil	D149...	380	250–375	250	350
Dielec Const					
60 Cycles	D150...	7.4	9–16	15	15
10^6 Cycles	D150...	—	5	5	5
Dissip Factor					
60 Cycles	D150...	—	0.15–0.60	0.5	0.15
10^6 Cycles	D150...	0.10	0.1–0.2	0.09	0.13
Arc Resistance, sec	D495...	180	7–20	10–20	5–20
FABRICATING PROPERTIES					
Bulk Factor	.....	2.4	2.5–4.0	4.6–8.0	2.5
Compression Molding					
Pressure, 1000 psi	.....	2–5	2–6	2–6	2–6
Temperature, F	.....	285–350	300–360	300–350	300–350
Transfer Molding					
Pressure, 1000 psi	.....	2–10	2–12	2–12	2–12
Temperature, F	.....	285–350	300–350	300–350	300–350
Mold Shrinkage, in./in.	.....	0.004	0.005–0.010	0.003–0.006	0.005–0.008
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	400	212–300	212–225	225–260
Heat Dist Temp, F	D648...	335	220–270	220–280	250–300
CHEMICAL RESISTANCE		Severely attacked by strong acids and strong alkalis. Effects of dilute acids, alkalis and organic solvents vary with the reagent. Chemical resistance varies with the particular formulation and not all materials of a type are equally resistant			
USES		Mechanical applications include pulleys, wheels, motor housings, handles. Electrical uses include coil forms, ignition parts, condenser housings, fuse blocks, instrument panels. Thermal applications include handles, appliance connector plugs. Chemical uses include photographic development tanks, rayon spinning buckets and parts, milking machine cups. Decorative uses include radio and television cabinets, handles, knobs, buttons			

Cast Phenolics

Type →		Type I—Mechanical and Chemical	Type II—General Purpose Decorative	Type III—General Purpose Transparent
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792...	1.31	1.32	1.33
Coef of Ther Exp, per °F	D696...	3.3–4.4 x 10^{-5}	3.3–5.5 x 10^{-5}	4.7–6.6 x 10^{-5}
Water Absorption (24 hr), %	D570...	0.35–0.40	0.32–0.35	0.3–2.0
Flammability (>0.050 in.)	D635...	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638...	4–5 x 10^5	3–4.5 x 10^5	1–3 x 10^5
Tensile Strength, 1000 psi	D638...	6–9	5–7.2	2.5–4.5
Hardness (Rockwell)	D785...	M93–120	M90–105	R98–120
Impact Strength (Izod notched), ft-lb/in	D256...	0.25–0.40	0.30–0.45	0.23–0.35
Mod of Elast in Flexure, psi	D790...	3–5 x 10^5	3–5 x 10^5	1–3 x 10^5
Flexural Strength, 1000 psi	D790...	11–17	10–15	4–7
Compressive Yield Strength (1% offset), 1000 psi	D695...	14–18	12.8–15.8	4.5–6.5
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257...	1–7 x 10^{12}	1–3 x 10^{12}	3 x 10^{11}
Dielectric Strength (short time), v/mil	D149...	350–400	300–450	75–250
Dielectric Constant				
60 Cycles	D150...	6.5–7.5	15–20	20–30
10^6 Cycles	D150...	4.0–5.5	5.0–11.0	7–8
Loss Factor				
60 Cycles	D150...	0.05–0.9	0.4–4.0	5.0–17.0
10^6 Cycles	D150...	0.15–0.35	0.05–1.10	0.6–0.8
FABRICATING PROPERTIES	—	Castings produced by pouring resins into molds (generally made of lead). Resins converted to solid by heating several days at atmospheric pressure and temperatures below 212 F. After oven baking, casting is removed from mold and is ready for machining and polishing		
HEAT RESISTANCE				
Heat Dist Temp, F				
66 Psi	D648...	—	150–160	125–135
264 Psi	D648...	165–175	130–140	100–125
CHEMICAL RESISTANCE		Unless specially formulated, do not resist strong alkalis or strong acids. Dilute alkalis: slight to marked attack depending on alkali. Dilute acids: no effect or slight decomposition depending on acid. Continuous immersion in acetone, Cellosolve, methyl alcohol or ethyl alcohol results in noticeable attack, depending on time, temperature and hardness of cast resin		
USES		Drill and saw jigs, stretch press molds and dies for fabricating aircraft parts, furniture hardware, instrument casings, sporting goods, costume and ornamental jewelry		

Cast Allyls and Polyesters

Type ➡		Allyl	Rigid Polyester	Nonrigid Polyester
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792...	1.30–1.45	1.12–1.46	1.06–1.25
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.116–0.121	0.10–0.12	—
Coef of Ther Exp, per °F	D696...	2.8–5.6 x 10^{-5}	3.9–5.6 x 10^{-5}	—
Refractive Index	D542...	1.50–1.58	1.53–1.58	1.50–1.57
Specific Heat, Btu/lb/°F	.....	0.26–0.55	0.30–0.55	—
Water Absorption (24 hr), %	D570...	0.03–1.0	0.15–0.60	0.40–2.5
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638...	2–3 x 10^5	1.5–6.5 x 10^5	—
Tensile Strength, 1000 psi	D638...	4.5–7	4–10	0.9–1.9
Elongation (in 2 in.), %	D638...	—	<5	40–310
Hardness (Rockwell)	D785...	M92–118	M65–115	—
Impact Strength (Izod notched), ft-lb/in.	D256...	0.18–0.32	0.18–0.40	>7.0
Mod of Elast in Flexure, psi	.....	3–8 x 10^5	3–9 x 10^5	0.001–0.1 x 10^5
Flexural Strength, 1000 psi	D790...	6–14	7–19	—
Compressive Strength, 1000 psi	D695...	20–26	12–37	—
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257...	>10^{13}	>10^{13}	>10^{12}
Dielectric Strength (short time), v/mil	D149...	330–500	340–570	220–400
Dielectric Constant				
60 Cycles	D150...	3.2–5.2	2.8–4.4	4.2–7.0
10^6 Cycles	D150...	3.3–4.8	2.8–4.0	3.7–6.1
Dissipation Factor				
60 Cycles	D150...	0.006–0.02	0.003–0.04	0.02–0.18
10^6 Cycles	D150...	0.024–0.045	0.006–0.04	0.02–0.06
Arc Resistance, sec	D495...	120–150	115–135	125–145
HEAT RESISTANCE				
Max Rec Svc Temp, F	D648...	300	250–300	200–250
Heat Dist Temp, F	.....	120–320	120–420	250
CHEMICAL RESISTANCE		Attacked by oxidizing acids. Slightly attacked by strong alkalis. Resistant to organic solvents	Slightly to heavily attacked by strong acids. Attacked by strong alkalis, ketones and chlorinated solvents	
USES		Castings used for aircraft glazing, electrical components, decorative applications. Resins used for premix and prepreg molding materials, matched metal molding and hand lay-up molding		

Polyethylenes

Type →		Low Density			Medium Density	High Density
		Melt Index 0.3–3.6	Melt Index 6–26	Melt Index 200	Melt Index 0.3–8.0	Melt Index 0.3–8.0
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792	0.910–0.930	0.918–0.925	0.910	0.926–0.941	0.941–0.970
Ther Cond, Btu/hr/sq ft/°F/ft	C177	0.19	0.19	0.19	0.19	0.24
Coef of Ther Exp, 10^{-5} per °F	D696	8.9–11.0	8.9–11.0	11.0	8.3–16.7	6.9–11.0
Refractive Index	D542	1.51	1.51	1.51	1.51	1.51
Spec Ht, Btu/lb/°F	D570	0.53–0.55	0.53–0.55	0.53–0.55	0.53–0.55	0.53–0.55
Water Absorption (24 hr), %	D635	<0.01	<0.01	<0.01	<0.01	<0.01
Flammability, ipm		1.0	1.0	1.0	1.0	1.0
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638	0.21–0.27	0.20–0.24	—	0.35–0.90	0.85–1.6
Ten Str, 1000 psi	D412	1.4–2.5	1.4–2.0	0.9–1.1	1.6–2.5	3.5–5.5
Elong (in 2 in.), %	D412	500–725	125–675	80–100	—	25-700
Hardness (Shore)	D785	C73, D50–52	C73, D47–53	D45	D45–65	D63–70
Impact Str (Izod notched), ft-lb/in.	D256	—	—	—	—	1–12
Brittleness Temp, F		<–94	<–4	<14	<–75	<–100
Stiffness in Flex, 1000 psi	D747	13–27	12–30	10	—	55–120
Shear Str, 1000 psi		1.6–1.85	1.4–1.7	1	3.0–4.2	3.5–4.5
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257	10^{17}–10^{19}	10^{17}–10^{19}	10^{17}–10^{19}	10^{17}–10^{19}	10^{17}–10^{19}
Dielec Str (short time), v/mil	D149	550–1000	550–1000	550–1000	550–1000	550–1000
Dielec Const	D150	2.3	2.3	2.3	2.3	2.3
Dissip Factor	D150	<0.0005	<0.0005	<0.0005	<0.0005	<0.0005
FABRICATING PROPERTIES						
Bulk Factor		1.8–2.0	1.8–2.0	1.8–2.0	1.8–2.0	1.8–2.0
Compression Molding						
Pressure, 1000 psi		—	—	—	—	1.0–3.5
Temperature, F		—	—	—	—	300–450
Injection Molding						
Pressure, 1000 psi		5–22	5–15	2–10	10–15	5–22
Temperature, F		275–650	275–650	250–350	300–500	275–650
Mold Shrinkage, in./in.		0.02–0.05	0.01–0.04	0.01–0.02	0.02–0.05	0.02–0.05
Apparent (bulk) Density		30–33	30–33	30–33	—	29–30
HEAT RESISTANCE						
Softening Point, F		196–230	180–230	156	—	268
CHEMICAL RESISTANCE		Excellent resistance to acids and alkalis at normal temperatures, except oxidizing acids such as nitric, chlorosulfonic and fuming sulfuric. Below 122 F, insoluble in organic solvents; at higher temperatures soluble to varying degrees in hydrocarbons and halogenated hydrocarbons, but insoluble in more polar liquids. Generally, a higher melt index material has greater solubility				
USES		Injection moldings: kitchen utility ware, toys, process tank liners, closures, packages, sealing rings, battery parts. Blow moldings: squeeze bottles for packaging, containers for drugs. Film: wrapping materials for food, clothes, other items. Wire and cable: high frequency insulation, jacketing. Pipe: chemicals handling, irrigation systems, natural gas transmission				Refrigerator parts, buoyancy applications, packaging, structural housing panels, pipe insulation, cold storage insulation, toys

Silicones

Type and Filler →		General—Mineral	Improved Impact—Glass Fiber	High Impact—Glass Fiber
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792...	1.8–2.0	1.8–2.0	1.65–2.00
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.089–0.097	0.089–0.097	0.089–0.097
Coef of Ther Exp, per °F	D696...	2.78–3.23 x 10^{-5}	3.17–3.23 x 10^{-5}	0.45 x 10^{-5}
Water Absorption (24 hr), %	D570...	0.2–0.4	0.4–0.5	0.1–0.5
Flammability, ipm	D635...	0–78	0–60	25–100
MECHANICAL PROPERTIES				
Tensile Strength, 1000 psi	D651...	4–4.3	4–4.3	4.4–5
Hardness (Rockwell)	D785...	M89	M89	M45
Impact Strength (Izod notched), ft-lb/in.	D256...	0.25–0.30	0.33–0.38	3.00–6.00
Mod of Elast in Flexure, psi	D790...	10–13 x 10^5	9–11 x 10^5	15–19 x 10^5
Flexural Strength, 1000 psi	D790...	6.8–7.5	6.1–6.4	9–14
Compressive Strength, 1000 psi	D695...	16–20	12–16	10–15
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257...	>3.4 x 10^{13}	>3.4 x 10^{13}	>5 x 10^{13}
Dielectric Strength (short time), v/mil	D149...	350–400	300–400	250–400
Dielectric Constant				
60 Cycles	D150...	4.1–4.5	5.1–5.3	4.8–5.0
10^6 Cycles	D150...	3.8–4.3	4.9–5.1	3.6–5.1
Dissipation Factor				
60 Cycles	D150...	0.010–0.014	0.008–0.011	0.006–0.030
10^6 Cycles	D150...	0.006–0.010	0.007–0.011	0.005–0.020
Arc Resistance, sec	D495...	250–420	250–350	20–350
Loss Factor				
60 Cycles	D150...	0.041–0.063	0.041–0.058	0.029–0.035
10^6 Cycles	D150...	0.023–0.043	0.034–0.056	0.025–0.077
FABRICATING PROPERTIES				
Bulk Factor		2.1–2.6	2.3–2.8	6–9
Compression Molding				
Pressure, 1000 psi		2–4	2–4	1–5
Temperature, F		300–350	300–350	300–350
Transfer Molding				
Pressure, 1000 psi		3.5–15	3.5–15	4.5–15
Temperature, F		300–350	300–350	300–350
Mold Shrinkage, in./in.		0.006–0.010	0.005–0.008	0.003–0.005
HEAT RESISTANCE				
Max Res Svc Temp, F		>450	>450	>450
Heat Dist Temp, F	D648...	>300	>300	>300
CHEMICAL RESISTANCE		Resistant to aviation gasoline, lubricating oil, and sulfuric and hydrochloric acids. Slightly softened and pitted by sodium hydroxide, except some of the mineral-filled materials. Should be tested if resistance to ketones, toluene, ethylenes, etc., is required		
USES		Motor slot wedges, terminal boards, connector plugs, switches and insulators, aircraft brake assemblies, jet engine parts, aircraft ignition systems, guided missile parts		

Polystyrenes and Polymethylstyrenes

Type →		Methylstyrene		Polystyrene		
		Polymethyl-styrene	Methylstyrene-Acrylonitrile	General Purpose	Heat Resistant	Glass Fiber-Filled
PHYSICAL PROPERTIES	ASTM					
Specific Gravity	D792...	1.03	1.06	1.04–1.07	1.04–1.07	1.32–1.35
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	—	—	0.058–0.080	0.058–0.080	—
Coef of Ther Exp, 10^{-5} per °F	D696...	—	—	3.3–4.4	3.3–4.4	—
Spec Ht, Btu/lb/°F	.....	—	—	0.32–0.35	0.32–0.35	—
Refractive Index	D542...	1.581	1.559	1.58–1.60	1.58–1.60	Low
Transmittance (luminous), %	.....	Transparent	Transparent	0–93	0–93	—
Water Absorption (24 hr), %	D570...	0.05	0.31	0.03–0.05	0.03–0.07	0.07
Flammability, ipm	D635...	Slow	Slow	1.0–1.5	1.0–1.5	—
MECHANICAL PROPERTIES						
Mod of Elast in Tension, 10^5 psi	D638...	—	—	4–5	4–5	12
Ten Str, 1000 psi	D638...	6.6	9.3	5–8	7–8.5	10–14.5
Elong (in 2 in.), %	D638...	2.2	2.5	1.5–2.4	1.5–2.4	0.75–1.0
Hardness (Rockwell)	D785...	M76	M83	M68–80	M65-85	M80–90
Impact Str (Izod notched), ft-lb/in.	D256...	0.33	0.40	0.25–0.35	0.25–0.40	1.5–2.5
Mod of Elast in Flex, 10^5 psi	.....	4.0	4.6	4–5	4–5	—
Flex Str, 1000 psi	D790...	13	16	8–15	11–16	—
Compr Str, 1000 psi	D695...	—	—	11.5–16	11.5–16	16–19
ELECTRICAL PROPERTIES						
Vol Res, ohm-cm	D257...	2.63×10^{14}	2.65×10^{11}	10^{18}–10^{19}	10^{18}–10^{19}	$0.1–6.7 \times 10^{15}$
Dielec Str (short time), v/mil	D149...	890	610	>500	>500	440–496
Dielec Const						
60 Cycles	D150...	—	—	—	—	3.11–3.22
10^6 Cycles	D150...	2.48	2.81	—	2.45–2.65	2.94–2.98
Dissip Factor						
60 Cycles	D150...	—	—	—	—	0.0364–0.0490
10^6 Cycles	D150...	0.0006	0.0078	—	0.0001–0.0005	0.0019–0.0025
Arc Resistance, sec	D495...	—	—	—	—	95–109
FABRICATING PROPERTIES						
Bulk Factor	.....	—	—	1.6–2.3	1.6–2.3	—
Compression Molding						
Pressure, 1000 psi	.....	1–8	1–8	1–7.5	1–10	2–5
Temperature, F	.....	300–375	300–375	275–400	275–400	275–350
Injection Molding						
Pressure, 1000 psi	.....	10–30	10–30	10–24	10–24	15–20
Temperature, F	.....	400–550	400–550	325–650	375–600	450–575
Mold Shrinkage, in./in.	.....	0.0046	0.0035	0.002–0.008	0.002–0.008	0.001–0.005
Joining	.....	Can be solvent welded with ethyl or butyl acetate, methylethyl ketone, cyclohexanone or trichloroethylene; also (polymethylstyrene) xylene or toluene. Better bonds obtained by adding ground resin granules to these solvents		—	—	—
HEAT RESISTANCE						
Max Rec Svc Temp, F	.....	210	212	140–160	160–180	—
Heat Dist Temp, F	D648...	213	215	165–190	182–206	218–230
CHEMICAL RESISTANCE		Same as polystyrenes	Resists aliphatic hydrocarbons, gasoline, essential oils, vegetable and mineral oils	Good resistance to alkalis, salts, lower alcohols, glycols, water. Fair resistance to mineral and vegetable oils. Soluble in aromatic and chlorinated hydrocarbons. Softened or attacked by higher alcohols, gasoline, strong oxidizing acids, chlorine and bromine waters		
USES		Radio cabinets, housewares and household utility parts, refrigerator parts, decorative lighting, packaging, electronic components	Same as polymethylstyrene. Also metering sight glasses, fan blades, combs, automotive interior parts, machine housings	Electrical parts, including storage battery cases, insulators, coil forms. Fluorescent light fixtures, rigid containers, instrument panels, light machine housings, nameplates, refrigerator parts, housewares, toys		Household utility, cases, meter housings, cabinet doors, storage drawers

Modified Polystyrenes

Type ➡		Heat & Chemical Resistant	Medium Impact	High Impact	Extra High Impact
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.05–1.11	1.05–1.07	1.04–1.08	1.01–1.08
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.046–0.072	0.024–0.072	0.024–0.072	0.02–0.10
Coef of Ther Exp, per °F	D696...	3.8×10^{-5}	$3.3–4.4 \times 10^{-5}$	$3.6–4.7 \times 10^{-5}$	$4.7–9.9 \times 10^{-5}$
Refractive Index	D542...	1.58–1.60	—	—	—
Spec Ht, Btu/lb/°F	.....	0.32–0.35	0.30–0.35	0.30–0.35	0.33–0.38
Water Absorption (24 hr), %	D570...	0.1–0.3	0.03–0.07	0.04–0.08	—
Flammability, ipm	D635...	0.4–0.7	1–2	1–2	0.06–1.0
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	D638...	$4–6 \times 10^5$	$4.2–4.6 \times 10^5$	$3.3–4.5 \times 10^5$	$2.0–3.5 \times 10^5$
Ten Str, 1000 psi	D638...	10–11	3.5–6.8	3.5–6.5	3–4.5
Elong (in 2 in.), %	D638...	1–3	5.5–7.5	5–35	20–100
Hardness (Rockwell)	D785...	M78–88	M70–80	M30–55	M30–65
Impact Str (Izod notched), ft-lb/in	D256...	0.25–0.50	0.6–1.0	1.0–3.0	4.8–15.0
Mod of Elast in Flex, psi	.....	$4–6 \times 10^5$	$3–5 \times 10^5$	$3–4.5 \times 10^5$	$2.5–4 \times 10^5$
Flex Str, 1000 psi	D790...	11–17	No failure	No failure	No failure
Compr Yld Str, 1000 psi	D695...	12–17	7–9	5–8.5	3.5–6.5
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	$10^{13}–10^{17}$	$10^{16}–10^{17}$	$10^{15}–10^{16}$	$10^{14}–10^{16}$
Dielec Str (short time), v/mil	D149...	400–600	>500	>450	>400
Dielec Const					
60 Cycles	D150...	2.7–3.4	2.55[a]	2.45–2.70[a]	2.55–2.93[a]
10^6 Cycles	D150...	2.7–3.1	—	—	—
Dissipation Factor					
60 Cycles	D150...	0.001–0.008	0.0004–0.0008[a]	0.0004–0.01[a]	0.007–0.1[a]
10^6 Cycles	D150...	0.001–0.008	—	—	—
FABRICATING PROPERTIES					
Bulk Factor	.....	1.6–2.3	1.6–2.3	1.6–2.3	—
Compression Molding					
Pressure, 1000 psi	.....	1–5	1–7.5	1–8	1–5
Temperature, F	.....	325–450	325–450	325–475	350–475
Injection Molding					
Pressure, 1000 psi	.....	10–24	10–24	10–24	10–24
Temperature, F	.....	400–700	300–600	350–600	375–525
Mold Shrinkage, in./in.	.....	0.002–0.008	0.002–0.008	0.002–0.008	0.005–0.009
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	175–190	140–165	125–165	125–155
Heat Dist Temp, F	D648...	200–220	160–180	155–175	150–165
CHEMICAL RESISTANCE		More resistant to attack by solvents, oils and other organic liquids than other polystyrenes	Similar to general purpose polystyrene		
USES		Battery cases, coil forms, drafting instruments, sight glasses on pressure lubricating systems, thermostat housings	Coat hangers, toilet seats, toys, novelties, containers, packaging	Refrigerator door panels, drawers and crispers; knobs, toys and novelties, vacuum forming sheets	Freezer lids, battery cases, action toys, children's furniture, tote boxes, trays

[a]Average for wide frequency range.

Ureas

Grade[a] →		1	2
PHYSICAL PROPERTIES	ASTM		
Specific Gravity	D792...	1.47–1.52	1.52
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.17–0.244	—
Coef of Ther Exp, per °F	D696...	1.22–1.50 x 10^{-5}	—
Transmittance (luminous), %	.....	21.8	0
Water Absorption (24 hr), %	D570...	0.4–0.8	—
Flammability	D635...	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	D638...	13–16 x 10^5	—
Tensile Strength, 1000 psi	D638...	5–10	—
Elongation (in 2 in.), %	D638...	1.0	—
Hardness (Rockwell)	D785...	E94–97, M116–120	—
Impact Strength (Izod notched), ft-lb/in	D256...	0.24–0.35	0.26–0.275
Flexural Strength, 1000 psi	D790...	10–18	10–13
Compressive Strength, 1000 psi	D695...	25–38	—
Shear Strength, 1000 psi	.....	11–12	—
ELECTRICAL PROPERTIES			
Volume Resistivity, ohm-cm	D257...	0.5–5 x 10^{11}	5–8 x 10^{10}
Dielectric Strength (short time), v/mil	D149...	300–400	340–370
Dielectric Constant			
60 Cycles	D150...	7.0–9.5	7.2–7.3
10^6 Cycles	D150...	6.4–6.9	6.4–6.5
Dissipation Factor			
60 Cycles	D150...	0.035–0.043	0.042–0.044
10^6 Cycles	D150...	0.028–0.032	0.027–0.029
Loss Factor			
60 Cycles	.....	0.24–0.38	0.30–0.32
10^6 Cycles	.....	0.18–0.22	0.17–0.19
Arc Resistance, sec	D495...	80–130	85–110
FABRICATING PROPERTIES			
Bulk Factor	.....	2.4–3.0	2.5
Compression Molding			
Pressure, 1000 psi	.....	2–8	2–5
Temperature, F	.....	275–350	275–320
Mold Shrinkage, in./in.	.....	0.006–0.014	0.007–0.008
HEAT RESISTANCE			
Heat Dist Temp, F	D648...	266–280	—
CHEMICAL RESISTANCE		High resistance to organic solvents, oils and greases. Poor resistance to acids and alkalis, depending on concentration	
USES		Such housings as radio, television, business machines, food equipment. Toilet seats, household electrical switches and plugs, buttons and cosmetic containers	Low cost items. Available only in dark color. Especially suited for electric switch plates, wiring devices and electrical parts requiring high arc resistance

[a]ASTM D705-55.

Polyvinyl Chloride and Copolymers

Type →		Polyvinyl Chloride, Polyvinyl Chloride-Acetate			Vinylidene Chloride[a]
		Nonrigid—General	Nonrigid—Electrical	Rigid—Normal Impact	
PHYSICAL PROPERTIES	ASTM				
Specific Gravity	D792...	1.20–1.55	1.16–1.40	1.32–1.44	1.68–1.75
Ther Cond, Btu/hr/sq ft/°F/ft	D325...	0.07–0.10	0.07–0.10	0.07–0.10	0.053
Coef of Ther Exp, 10^{-5} per °F	D696...	—	—	2.8–3.3	8.78
Refractive Index	D542...	—	—	—	1.60–1.63
Spec Ht, Btu/lb/°F	D570...	—	—	—	0.32
Water Absorption (24 hr), %	D635...	0.2–1.0	0.40–0.75	0.03–0.40	>0.1
Flammability	.....	Self-extinguishing	Self-extinguishing	Self-extinguishing	Self-extinguishing
MECHANICAL PROPERTIES					
Mod of Elast in Tension, 10^5 psi	D412...	0.004–0.03	0.01–0.03	3.5–4.0[b]	0.7–2.0
Ten Str, 1000 psi	D412...	1–3.5	2–3.2	5.5–9	4–8, 15–40
Elong (in 2 in.), %	D638...	200–450	220–360	5–25	15–25, 20–30
Hardness (Rockwell)	D785...	—	—	R117–120	M50–65
Hardness (Shore)	D676...	A50–100	A78–100	D70–85	>A95
Impact Str (Izod notched), ft-lb/in.	D256...	Variable	Variable	0.25–1.2	2–8, 0.053
Mod of Elast in Flex, psi	D790...	—	—	3.8–5.4 x 10^5	—
100% Modulus, psi	.....	1300–1750	1200–2800	—	—
Flex Str, 1000 psi	D790...	—	—	12.5–16	15–17, flexible
Compr Str, 1000 psi	D695...	—	—	11–12	—
Compr Yld Str, 1000 psi	D695...	—	—	10–11	75–85
Cold Flex Temp, F	D1043..	−70 to 0	−7 to +59	—	—
Cold Bend Temp, F	.....	−40 to −4	−49 to −4	—	—
ELECTRICAL PROPERTIES					
Vol Res, ohm-cm	D257...	1–700 x 10^{12}	4–300 x 10^{11}	10^{14}–>10^{16}	10^{14}–10^{16}
Dielec Str (short time), v/mil	D149...	—	24–500	725–1400	—
Dielec Const (60 cycles)	D150...	5.5–9.1	6.0–8.0	2.3–3.7	3–5
Dissip Factor (60 cycles)	D150...	0.05–0.15	0.08–0.11	0.020–0.03	0.03–0.15
Loss Factor (60 cycles)	D150...	—	1.0–1.2	0.030–0.072	—
FABRICATING PROPERTIES					
Bulk Factor	.....	2.4–2.6	2.4–2.6	2.0–2.4	—
Compression Molding					
Pressure, 1000 psi	.....	0.5–2	0.5–2	>1	0.5–5
Temperature, F	.....	285–350	285–350	275–400	250–350
Injection Molding					
Pressure, 1000 psi	.....	7–15	12–20	>20	10–30
Temperature, F	.....	320–350	325–375	300–375	300–400
Mold Shrinkage, in./in.	.....	0.02–0.05	0.02–0.06	0.001–0.004	0.008–0.012
Extrusion Temp, F	.....	325–400	350–385	—	<375
HEAT RESISTANCE					
Max Rec Svc Temp, F	.....	150–220	140–220	150–165	170–212
Heat Dist Temp, F					
66 Psi	D648...	—	—	170–185	190–210
264 Psi	D648...	—	—	140–170	130–150
Softening Point, F	.....	—	—	—	240–280
CHEMICAL RESISTANCE		Generally resistant to alkalis and weak acids. Moderately to not resistant to strong acids. Not resistant to ketones and esters; aromatic hydrocarbons produce swelling			Excellent to all acids and most common alkalis[c]
USES		Parts made by molding, high speed extrusion, calendering. Blown extruded film. Vacuum cleaner parts, handlebar grips, doll parts, hair curlers, safety goggle cups, grommets, toy tires, garden hose, and protective garments	Parts made by calendering, extrusion. Insulation and jacketing for: communication and low tension power wire and cable, building wiring, appliance and machine tool cords, and switchboard cable	Parts made by calendering, laminating, molding, extrusion. Fume hoods and ducts, storage tanks, chemical piping, plating tanks, phonograph records. Sheets and shapes for decorative panels, other building uses	Extrusions: gasket rods, valve seats, flexible chemical tubing and pipe, tape for wrapping joints, chemical conveyor belts. Moldings: spray-gun handles, acid dippers, parts for rayon producing equipment

[a]Where two values or ranges are given, they represent unoriented and oriented forms, respectively.
[b]Modulus of elasticity in compression. [c]Unaffected by aliphatic and aromatic hydrocarbons, alcohols, esters, etc.

Polyvinyl Alcohol, Butyral and Formal

Material →		Polyvinyl Alcohol	Polyvinyl Butyral	Polyvinyl Formal
PHYSICAL PROPERTIES	ASTM			
Specific Gravity	D792...	1.21–1.31	1.07–1.20	1.2–1.4
Ther Cond, Btu/hr/sq ft/°F/ft	C177...	0.46	—	0.089
Coef of Ther Exp, per °F	D696...	3.88–6.65 x 10^{-5}	4.4–12.7 x 10^{-5}	3.55–4.27 x 10^{-5}
Refractive Index	D542...	1.49–1.53	1.48–1.49	1.5
Specific Heat, Btu/lb/°F	.....	0.3	0.4	—
Transmittance (luminous), %	.....	[a]	85–91	80–90
Water Absorption (24 hr), %	D570...	>30	1.0–3.0	0.5–3.0
Flammability	D635...	Slow burning	Slow burning	Slow burning
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638...	—	3.5–4.0 x 10^5	5–7 x 10^5
Tensile Strength, 1000 psi	D638...	1–5	4–8.5	9–11
Elongation (in 2 in.), %	D638...	300–600	5–60	5–20
Hardness (Rockwell)	D785...	—	L95	M85
Hardness (Shore A)	.....	10–100	—	—
Impact Strength (Izod notched), ft-lb/in.	D256...	—	0.74–1.02	0.8–20
Mod of Elast in Flex, psi	.....	—	—	5–6 x 10^5
Flexural Strength, 1000 psi	D790...	—	10	17–18
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257...	[b]	>10^{14}	—
Dielectric Strength (short time), v/mil	D149...	[b]	400	300–600
Dielectric Constant				
60 Cycles	D150...	[b]	3.61	3.7
10^6 Cycles	D150...	[b]	3.33	3.0
Dissipation Factor				
60 Cycles	D150...	[b]	0.0070	0.010
10^6 Cycles	D150...	[b]	0.0065	0.023
FABRICATING PROPERTIES				
Compression Molding				
Pressure, 1000 psi	.....	5–15	1–2	1–10
Temperature, F	.....	250–300	320–400	275–325
Injection Molding				
Pressure	.....	—	11–15	14–32
Temperature, F	.....	—	400	325–425
Mold Shrinkage, in./in.	.....	—	—	0.0015–0.0035
HEAT RESISTANCE				
Max Rec Svc Temp, F	.....	—	115	130–165
Heat Dist Temp, F	D648...	—	115–140	155–185
CHEMICAL RESISTANCE		Good resistance to organic solvents and petroleum. Attacked by strong acids. Softened or dissolved by weak acids and by alkalis	Resistant to alkalis, aliphatic hydrocarbons, and most oils. Attacked by acids, alcohols, esters and ketones. Butyral used with wider range of solvents than Formal	
USES		Adhesives and binders, textile sizing, coating and sizing for paper, thickening agents. Molded: chemical and oxygen tubing, gaskets and diaphragms. Film: airtight bags, packaging for chemicals	Plasticized form used as interlayer for safety glass. Solution uses: adhesive primer, metal conditioner, cloth waterproofing	Base for electrical insulating enamel with high heat resistance. Metal wire and cable coatings requiring high toughness and adhesion

[a] Transparent to opaque.
[b] Under atmospheric conditions enough water will be absorbed to make most electrical measurements useless.

Acetal, Polycarbonate and Polypropylene

Material →		Acetal	Polycarbonate	Polypropylene
PHYSICAL PROPERT.ES	ASTM			
Specific Gravity	D792...	1.425	1.20	0.90–0.91
Ther Cond, Btu/hr/sq ft/°F/ft	.....	0.13	0.11	0.08
Coef of Ther Exp, per °F	D696...	4.5×10^{-5}	3.9×10^{-5}	6.2×10^{-5}
Specific Heat, Btu/lb/°F	.....	0.35	—	0.46
Water Absorption (24 hr), %	D570...	0.41	0.3	0.03
Flammability, ipm	D635...	1.1	Self-extinguishing	—
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	D638...	—	0.33×10^{5}[a]	1.55×10^{5}
Tensile Strength, 1000 psi	D638...	10.0	9.0–10.5	5.0
Elongation (total), %	D638...	15	60–100	500–700
Hardness (Rockwell)	D785...	M94, R120	M70, R118	R85–95
Impact Strength, ft-lb/in.				
Notched	D256...	1.4	12–16	1.02
Unnotched	D256...	—	>60	>17
Mod of Elast in Flex, psi	D790...	4.1×10^{5}	3.8×10^{5}	1.7×10^{5}[b]
Flexural Strength, 1000 psi	D790...	14.1	11–13	8.1[b]
Stiffness in Flex, 1000 psi	D790...	—	—	114–142
Compressive Strength, 1000 psi	D695...	5.2	11	—
Shear Strength, 1000 psi	D732...	9.5	9.2	—
Yield Strength, 1000 psi	D638...	—	8.0–9.0	4.3–4.9
Elongation (at yield), %	D638...	—	5	10–20
ELECTRICAL PROPERTIES				
Volume Resistivity, ohm-cm	D257...	$>4 \times 10^{13}$	2.1×10^{16}	$>10^{16}$
Dielectric Strength (short time), v/mil	D149...	500	400	769–820
Dielectric Constant				
60 Cycles	D150...	3.7	3.17	—
10^6 Cycles	D150...	3.7	2.96	2.0–2.1
Dissipation Factor				
60 Cycles	D150...	0.004	0.0090	—
10^6 Cycles	D150...	0.004	0.0100	0.0002–0.0003
Arc Resistance, sec	D495...	129	10–11	—
FABRICATING PROPERTIES				
Bulk Factor	D1182..	—	1.74	2.25
Injection Molding				
Pressure, 1000 psi	.....	15–25	15–20	Wide range
Temperature, F	.....	380–440	550–600	Wide range
Extrusion Temp, F	.....	—	—	340–430
Mold Shrinkage, in./in.	.....	0.01–0.04	0.005–0.007	0.015–0.030
HEAT RESISTANCE				
Max Rec Svc Temp, F	.....	185	—	—
Heat Dist Temp, F				
66 Psi	D648...	338	283–293	221
264 Psi	D648...	212	280–290	—
Melt Pt (crystalline), F	.....	347	514	330
CHEMICAL RESISTANCE		Excellent res to most organic solvents, including aliphatic and aromatic hydrocarbons. Not rec for use with strong acids and alkalis; should be tested for use with dilute acids and weak alkalis. Affected by ultra violet light	Insoluble in aliphatic hydrocarbons, ether and alcohols; partially soluble in aromatic hydrocarbons; soluble in chlorinated hydrocarbons; slowly decomp by alkaline substances. High stability to water and to mineral and organic acids	Res to most acids, alkalis and saline solutions, even at higher temp; res to organic solvents and polar substances. Above 175 F, soluble in such aromatic substances as toluene and xylene, and such chlorinated hydrocarbons as trichloroethylene
USES		Household: dinner plates, dishwasher and sewing machine parts. Automotive: gears, bushings, bearings. Also movie projector and typewriter parts	Coil forms, decorative and functional appliance parts, gears, automotive parts, housings, structural parts, electronic components, telephone accessories	Structural shapes, housewares, electronic equipment, automotive parts, rotating parts for typewriters and calculating machines. Also packaging (film)

[a] 212 F. [b] Tinius-Olsen.

Plastics Films

Type →	ASTM	Rigid Polyvinyl Chloride (incl copolymers)	Nonrigid Polyvinyl Chloride (incl copolymers)	Polyvinylidene Chloride (Saran)	PVC-Nitrile Rubber Blend	Polyvinyl Alcohol	Polyethylene
GENERAL PROPERTIES							
Method of Production[a]		Cast, calndr, extr	Cast, calndr, extr	Extr	Cast, calndr, extr	Cast	Calndr, extr
Forms Available		Sheet, rolls, tapes	Sheet, rolls, tapes, tubes	Rolls, tubes	Sheet, rolls, tapes, tubes	Rolls	Sheet, rolls, tapes, tubes
Clarity[c]		Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl, opaque	Trp, trl	Trl, opaque
Min Thickness, in.		0.001	0.0005	0.0005	0.001	0.001	0.00075
Max Width, in.		54	104	40	84	54	144
Area Factor, 1000 sq in./lb/mil[d]		19.5-22.5	20-23	16.3	22.8-23.7	21.6	30
PHYSICAL PROPERTIES							
Specific Gravity	D792	1.36-1.50	1.15-1.50	1.68	1.18-1.35	1.21-1.31	0.92
Ten Str, 1000 psi	D882	6.5-8.5	1-5	7-15	1.5-4.0	6-10	1.6-3.0
Elong, %	D882	5-25	50-500	25-40	250-500	400-600	200-800
Burst Str (Mullen), psi[e]	D774	—	9-20	30-70	—	185-235	48
Tear Str (Elmendorf), gm/mil	D689	20-150	30-1400	30	100-960	500-800	100-300
Fold Endurance[e]	D643	Poor	Good	500,000[g]	Excellent	Good	Good
Heat Seal Temp Range, F[f]		260-400	200-400	285	220-350	300-400	250-375
Water Absorp (24 hr), %	D570	Negligible	Negligible	Negligible	Negligible	> 30	Negligible
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	0.5 (0.005 in.) to 2.5 (0.001 in.)	0.7 (0.005 in.) to 8.0 (0.001 in.)	0.20	7.0	> 10	1.20-1.40[m]
Gas Perm, cu cm 100 sq in./24 hr[5]							
Oxygen		3 (0.005 in.) to 15 (0.001 in.)	50-30[m]	0.56[m]	—	—	550[m]
Nitrogen		—	—	0.11[m]	—	—	180[m]
Carbon Dioxide		11 (0.005 in.) to 55 (0.001 in.)	250-2000[m]	2.4[m]	—	—	2900[m]
CHEMICAL RESISTANCE							
Strong Acids	D543 or D1239	Excellent	Excellent	Excellent[h]	Good	Poor	Excellent[j]
Strong Alkalis		Excellent	Excellent	Good[i]	Good	Poor	Excellent
Greases and Oils		Good	Fair	Excellent	Excellent	Excellent	Fair
Solvents							
Ketone and Ester		Poor	Poor	Fair	Poor	Excellent	Good
Chlorinated		Fair	Fair	Fair	Fair	Excellent	Fair
Hydrocarbon		Excellent	Good	Excellent	Good	Excellent	Fair
PERMANENCE							
Max Cont Svc Temp, F		200-220	150-180	290	200	—	200
Min Svc Temp, F		-70	-50	Good	-40	—	-68
Resistance to Sunlight		Good	Good	Excellent	Fair	Excellent	Good[l]
Dimensional Change, %		Nil	Nil	Nil	Nil	High	Nil
Storage Stability[k]		Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
Flammability (rate of burning)		Self-extinguishing	Slow to self-extinguishing	Self-extinguishing	Slow to self-extinguishing	Slow	Slow

[a]Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[c]Trp = transparent; trl = translucent.
[d]Figures may vary with resin-plasticizer ratio.
[e]Properties particularly dependent on thickness.
[f]Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g]ASTM D643, Method A.
[h]Except sulfuric and nitric.
[i]Except ammonium hydroxide.
[j]Except nitric, fuming sulfuric and chlorosulfonic.
[k]Average warehouse conditions: 40-100 F, dry.
[m]0.001-in. film.

continued

Plastics Films—continued

Type →		Polytetra-fluoro-ethylene	Polytri-fluoromono-chloro-ethylene	Polystyrene (oriented)	Polyester (polyethylene terephthalate)	Rubber Hydrochloride	Ethyl Cellulose
GENERAL PROPERTIES	ASTM						
Method of Production[a]		Block	Extr	Extr	Extr	Cast	Cast, block, extr
Forms Available		Sheet, tapes	Sheet, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls, tapes	Sheet, rolls, tapes
Clarity[c]		Trp	Trp, trl	Trp, trl, opaque	Trp, opaque	Trp, trl, opaque	Trp
Min Thickness, in.		0.002	0.002	0.001	0.00025	0.0004	0.003
Max Width, in.		12	20	40	55	60	30
Area Factor, 1000 sq in./lb/mil[d]		13	12	26.1	20	24	24
PHYSICAL PROPERTIES							
Specific Gravity	D792	2.15	2.11	1.05-1.07	1.39	1.12-1.15	1.14-1.16
Ten Str, 1000 psi	D882	2-3	6.3-6.6	7-12	17-28	5-6	6-10
Elong, %	D882	200-250	90-200	3-10	70-130[m]	350-500	20-35
Burst Str (Mullen), psi[e]	D774	—	42	30-60	45[m]	—	30-86
Tear Str (Elmendorf), gm/mil	D689	—	200-350	2-8	18	1000-1500	2-15
Fold Endurance[e]	D643	—	—	—	Excellent	10^4-10^6	2700
Heat Seal Range, F[f]		Not heat sealable	415-450	220-300	490	225-350	—
Water Absorp (24 hr), %	D570	None	None	0.04-0.06	Negligible	Negligible	Low
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	—	0.00	6.2	1.8[m]	0.5-15.5	10-50
Gas Perm, cu cm/100 sq in./24 hr[e]							
Oxygen		—	0.76[m]	213	5.7[m]	2-405	—
Nitrogen		—	5.5[m]	42	0.9[m]	—	—
Carbon Dioxide		—	8.0[m]	926	17.5[m]	36-2616	—
CHEMICAL RESISTANCE							
Strong Acids	D543 or D1239	Excellent	Excellent	Good	Excellent	Good	Poor
Strong Alkalis		Excellent	Excellent	Excellent	Excellent	Good	Excellent
Greases and Oils		Excellent	Excellent	Good	Excellent	Excellent	Good
Solvents							
Ketone and Ester		Excellent	Excellent	Poor	Excellent	Fair	Poor
Chlorinated		Excellent	Excellent	Good	Excellent	Fair	Poor
Hydrocarbon		Excellent	Excellent	Good	Excellent	Excellent	Fair
PERMANENCE							
Max Cont Svc Temp, F		565-585	300-395	160-180	490	205	210-275
Min Svc Temp, F		-90	-120	Good	-80	-20	-75
Resistance to Sunlight		Excellent	Excellent	Fair	Fair	Fair	Good
Dimensional Change, %		Nil	Nil	Nil	Nil	Slight	Slight
Storage Stability[k]		Excellent	Excellent	Good	Excellent	Good	Excellent
Flammability (rate of burning)		Nil	Nil	Slow	Self-extinguishing	Self-extinguishing	Slow

[a]Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[c]Trp = transparent; trl = translucent.
[d]Figures may vary with resin-plasticizer ratio.
[e]Properties particularly dependent on thickness.
[f]Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[k]Average warehouse conditions: 40-100 F, dry.
[m]0.001-in. film.

Plastics Films—concluded

Type ➡		Cellophane		Cellulose			
		Plain	Coated	Acetate[m]	Triacetate (42.5-44% acetyl)	Acetate Butyrate[m]	Nitrate
GENERAL PROPERTIES	ASTM						
Method of Production[a]		Extr	Extr	Extr, cast	Cast	Extr, cast	Cast, block
Forms Available		Sheet, rolls, tapes	Sheet, rolls	Sheet, rolls, tapes, tubes	Sheet, rolls	Sheet, rolls	Sheet, rolls
Clarity[c]		Trp	Trp	Trp, trl, opaque	Trp	Trp, opaque	Trp, trl, opaque
Min Thickness, in.		0.0009	0.0009	0.0005	0.003	0.0009	0.0005
Max Width, in.		60	60	60	45	40	50
Area Factor, 1000 sq in./lb/mil[d]		21.5	19.5	22	21.7	23.3	20
PHYSICAL PROPERTIES							
Specific Gravity	D792	1.45	1.40-1.55	1.25-1.35	1.28	1.16-1.18	1.42-1.46
Ten Str, 1000 psi	D882	8-19	7-16	9-14	9-11	6-9	10-11
Elong, %	D882	15-25	15-50	15-35	25-35	50-70	30-40
Burst Str (Mullen), psi[e]	D774	—	—	30-80	100-150	40-75	40-50
Tear Str (Elmendorf), gm/mil	D689	2-10	2-15	2-15	10-15	4-16	—
Fold Endurance[e]	D643	7000-22,000	—	1500-2000[n]	200-300[n]	900-1300[n]	50-250[g]
Heat Sealing Range, F[f]		Not heat sealable	200-350	400-500	—	—	—
Water Absorp (24 hr), %	D570	High	High	Low	Low	Low	Low
Water Vapor Perm, gm/100 sq in./24 hr[e]	E96-53T	High	0.2-1.0	10-40	10	60	—
Gas Perm, cu cm/100 sq in./24 hr[e]							
Oxygen		—	Low	3-6	—	—	—
Nitrogen		—	Low	—	—	—	—
Carbon Dioxide		—	Low	12-31	—	—	—
CHEMICAL RESISTANCE							
Strong Acids	D543 or D1239	Poor	Poor	Poor	Poor	Poor	Good
Strong Alkalis		Poor	Poor	Poor	Poor	Poor	Fair
Greases and Oils		Excellent	Good[l]	Good	Good	Fair	Fair
Solvents							
Ketone and Ester		Excellent	Poor[l]	Poor	Poor	Poor	Poor
Chlorinated		Excellent	Excellent	Poor	Poor	Poor	Fair
Hydrocarbon		Excellent	Fair	Good	Good	Good	Fair
PERMANENCE							
Max Cont Svc Temp, F		375	300-375	250-300	300-400	200-250	140
Min Svc Temp, F		0	0	–25	–25	–25	—
Resistance to Sunlight		Good	Good	Good	Good	Good	Poor
Dimensional Change, %		3-5	2-5	0.2-0.8	0.4	0.3	Nil
Storage Stability[k]		Good	Good	Excellent	Excellent	Excellent	Fair
Flammability (rate of burning)		Fast	Fast	Slow,70-100[b]	Self-extinguishing	Slow, 50-80[b]	Fast

[a]Cast = casting; calndr = calendering; extr = extrusion; block = block process.
[b]ASTM D 568.
[c]Trp = transparent; trl = translucent.
[d]Figures may vary with resin-plasticizer ratio.
[e]Properties particularly dependent on thickness.
[f]Unsupported film cannot be sealed on all types of heat sealers, since adhesion to metal sealer and distortion of film may be encountered.
[g]ASTM D 643, Method A.
[k]Average warehouse conditions: 40-100 F, dry.
[l]Coating attacked.
[n]ASTM D 643, Method B.

High Pressure Laminates (General Purpose)

Grade ➡	CE (canvas-phenolic)	A (asbestos paper-phenolic)	AA (asbestos cloth-phenolic)	G-3 (glass cloth-phenolic)
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.32	1.72	1.70	1.65
Ther Cond, Btu/sq ft/hr/°F/ft	0.17	—	—	—
Max Rec Svc Temp, F				
Short Time	300	400	400	410
Continuous	250	275	275	290
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.58	0.31	0.58	0.52
Crosswise	0.68	0.49	0.58	0.62
Water Absorption (24 hr), %				
1/16 In. Thick	1.3	1.3	2.5	1.8
1/8 In. Thick	0.9	0.8	2.0	1.2
1/2 In. Thick	0.5	0.5	1.2	0.7
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	11	10	12	23
Crosswise	9	8	10	20
Flex Str, 1000 psi				
Lengthwise	22	20	21	32
Crosswise	17	18	19	28
Compr Str (flatwise), 1000 psi	39	40	38	50
Mod of Elast in Flex, 10^5 psi				
Lengthwise	9	23	16	15
Crosswise	8	14	14	12
Impact Str (edgewise), ft-lb/in.				
Lengthwise	1.6	1.0	4.5	7.5
Crosswise	1.4	0.9	4.0	6.0
Hardness (Rockwell)	M105	M111	M103	M120
Bond Strength, psi	2200	800	2000	1000
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	500	225	85	700
1/8 In. Thick	360	160	70	600
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	45	10	—	—
Cond D48/50	5	—	—	—
Dissip Factor (10^6 cycles)				
Cond A	0.055	—	—	0.030
Cond D24/23	0.070	—	—	—
Dielec Const (10^6 cycles, cond A)	5.3	—	—	6.5
Insulation Res (cond 35/90), megohms	—	—	—	200
Arc Resistance, sec	10	10	10	10
AIEE Insulation Class	A	B	B	B
USES	Switchboard panels, circuit breaker and switch arms, terminal blocks, electrode supports for plating tanks, bases for motors, bobbin heads (often in combination with XX)	Mechanical parts in drying ovens, tenter rails	Rotor vanes, water pumping thrust washers, armature slot wedges, caustic resistant applications, electric appliance insulation	Armature slot wedges, structural parts requiring good electrical properties, electrical equipment operating at relatively high temperatures

High Pressure Laminates (General Purpose)—concluded

Grade →	G-5 (glass cloth–melamine)	G-10 (glass cloth–epoxy)	GPO-1 (glass mat–polyester)	Commercial and Trunk Fibre
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.9	1.78	1.5–1.9	1.15
Ther Cond, Btu/sq ft/hr/°F/ft	0.29	—	—	—
Max Rec Svc Temp. F				
Short Time	425	350	350	—
Continuous	300	250	250	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.31	—	1.1	—
Crosswise	0.34	—	—	—
Water Absorption (24 hr), %				
1/16 In. Thick	1.0	0.09	1.0	66
1/8 In. Thick	0.6	0.06	0.70	61
1/2 In. Thick	0.4	0.03	0.35	36
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	37	—	12	7.5
Crosswise	30	—	10	5.5
Flex Str, 1000 psi				
Lengthwise	65	72	23	14
Crosswise	50	63	20	12
Compr Str (flatwise), 1000 psi	70	—	40	20
Mod of Elast in Flex, 10^5 psi				
Lengthwise	17	—	15	—
Crosswise	15	—	13	—
Impact Str (edgewise), ft-lb/in.				
Lengthwise	12.0	14.4	12	3.5
Crosswise	9.0	10.6	10	2.9
Hardness (Rockwell)	M120	—	M100	R50
Bond Strength, psi	1700	2500	1000	1000
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	350	810	650	175
1/8 In. Thick	260	570	500	150
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	32	55	60	—
Cond D48/50	12	60	33	—
Dissip Factor (10^6 cycles)				
Cond A	0.016	0.0119	0.03	0.024
Cond D24/24	0.030	0.0126	0.06	0.030
Dielec Const (10^6 cycles, cond A)	6.8	4.8	4.3	—
Insulation Res (cond C96/35/90), megohms	100	1×10^5	—	—
Arc Resistance, sec	200	17	100	100
AIEE Insulation Class	B	B	B	—
USES	Switchboard panels, arc barriers and circuit breaker parts, armature and slot wedges, structural parts, electrical applications requiring high strength and arc resistance, high temperature applications	Printed circuits; other applications where high insulation resistance and dimensional stability, are required.	Panel boards, slot wedges, spacers, coil blocking, layer insulation, core corner protectors, terminal plates, structural applications	Washers, terminal block covers, insulating plates and switch covers, arch supporters, bobbin and coil spool heads, arc barriers, shoe fiber, switch and appliance insulation, knee pads, golf club head plates, deep formed parts, trunks, cases, wastebaskets, mill boxes

High Pressure Laminates (Mechanical)

Grade →	X (kraft paper–phenolic)	P (paper-plasticized phenolic)	PC (paper–phenolic)	ES 1, 2, 3 (paper base)[a]
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.35	1.33	1.34	—
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	—
Max Rec Svc Temp, F				
Short Time	275	275	250	—
Continuous	225	250	200	—
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.61	0.43	—	—
Crosswise	0.77	0.68	—	—
Water Absorption (24 hr), %				
1/16 In. Thick	4.0	2.2	3.2	2.5
1/8 In. Thick	2.3	1.5	2.0	1.8
1/2 In. Thick	0.9	—	—	—
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	20	12	10.5	12–15
Crosswise	16	9	8.5	8–12
Flex Str, 1000 psi				
Lengthwise	28	15	14	15
Crosswise	23	13	11	15
Compr Str (flatwise), 1000 psi	36	25	22	—
Mod of Elast in Flex, 10^5 psi				
Lengthwise	18	12	10	—
Crosswise	13	9	8	—
Impact Str (edgewise), ft-lb/in.				
Lengthwise	0.9	0.8	0.9	0.25
Crosswise	0.7	0.6	0.8	0.22
Hardness (Rockwell)	M110	M95	M75	M118
Bond Strength, psi	900	—	—	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	700	650	600	—
1/8 In. Thick	500	470	425	—
Dielec Str (par., step by step, 1/8 in. thick), kv				
Cond A	—	50	—	—
Cond D48/50	—	10	—	—
Dissip Factor (10^6 cycles)				
Cond A	—	—	—	—
Cond D24/23	—	—	—	—
Dielec Const (10^6 cycles, cond A)	—	—	—	—
Insulation Res (cond C96/35/90), megohms	—	—	—	—
Arc Resistance, sec	10	—	—	—
AIEE Insulation Class	A	A	A	A
USES	Structural parts for radio, aircraft and electrical equipment and switchgear. Terminal boards or panels, insulating washers, bushings, coil forms, brush-holder bushings	Insulating washers, terminal boards, plug and socket bases, switch bases and panels for subassemblies	Motor and generator terminal boards, insulating washers, terminal strips, switch bases and panels, staked terminal boards and strips	Engraved nameplates, signs

[a]ES-1 is melamine laminate; ES-2 is phenolic laminate; ES-3 has phenolic core, melamine base.

High Pressure Laminates (Mechanical)—concluded

Grade →	C (cotton canvas–phenolic)	L (cotton linen–phenolic)	MC (cotton fabric–melamine)	Bone Fibre
PHYSICAL PROPERTIES				
Density, gm/cu cm	1.35	1.34	1.5	1.3
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	0.17
Max Rec Svc Temp, F				
Short Time	275	275	275	—
Continuous	225	225	225	221
Coef of Ther Exp, 10^{-5} per °F				
Lengthwise	0.58	0.43	—	—
Crosswise	0.68	0.58	—	—
Water Absorption (24 hr), %				
1/16 In. Thick	4.4	2.0	2.2	55
1/8 In. Thick	2.5	1.4	1.6	48
1/2 In. Thick	1.2	0.8	1.0	25
MECHANICAL PROPERTIES				
Ten Str, 1000 psi				
Lengthwise	11	14	11	8
Crosswise	9	10	7	6
Flex Str, 1000 psi				
Lengthwise	22	23	23	15
Crosswise	18	18	18	13
Compr Str (flatwise), 1000 psi	37	35	45	30
Mod of Elast in Flex, 10^5 psi				
Lengthwise	10	11	—	12
Crosswise	9	8	—	8
Impact Str (edgewise), ft-lb/in.				
Lengthwise	2.3	1.3	0.9	3.0
Crosswise	2.2	1.2	0.9	2.4
Hardness (Rockwell)	M103	M105	M115	R80
Bond Strength, psi	2000	1700	1900	—
ELECTRICAL PROPERTIES				
Dielec Str (perp, short time), v/mil				
1/16 In. Thick	500	500	—	175
1/8 In. Thick	360	360	—	150
Dielec Str (par., step by step, 1/8 in. thick) kv				
Cond A	15	15	—	—
Cond D48/50	—	—	—	—
Dissip Factor (10^6 cycles)				
Cond A	—	0.055	—	—
Cond D24/23	—	0.070	—	—
Dielec Const (10^6 cycles, cond A)	6.0	5.8	—	—
Insulation Res (cond C96/35/90), megohms	—	—	—	—
Arc Resistance, sec	10	10	100	100
AIEE Insulation Class	A	A	—	—
USES	Gears and pinions, cams, pulleys, bobbin heads, chemical piping and fittings, bearings	Small gears and pinions, parts requiring intricate machining, breaker arms, fairleads and knobs	Plating barrel applications; others requiring good resistance to caustics	Gears, cams, fairleads, bushings, grommets, switch handles, terminal blocks, armature slot wedges, threaded and tapped pieces

High Pressure Laminates (Electrical)

Grade →	XX (paper-phenolic)	XXP (paper-phenolic)	XXX (paper-phenolic)	XXXP (paper-plasticized phenolic)	LE (cotton linen-phenolic)
PHYSICAL PROPERTIES					
Density, gm/cu cm	1.34	1.32	1.32	1.32	1.32
Ther Cond, Btu/hr/sq ft/°F/ft	0.17	0.17	0.17	0.17	0.17
Max Rec Svc Temp, F					
Short Time	300	275	300	275	300
Continuous	250	250	250	250	250
Coef of Ther Exp, 10^{-5} per °F					
Lengthwise	0.41	0.58	0.41	0.58	0.58
Crosswise	0.74	0.92	0.71	0.92	0.80
Water Absorption (24 hr), %					
1/16 In. Thick	1.3	1.3	0.8	0.40	1.3
1/8 In. Thick	0.9	0.9	0.5	—	0.8
1/2 In. Thick	0.5	—	0.3	—	0.5
MECHANICAL PROPERTIES					
Ten Str, 1000 psi					
Lengthwise	16	11	15	12	13.5
Crosswise	13	8.5	12	9.5	9.5
Flex Str, 1000 psi					
Lengthwise	18	18	18	21	18
Crosswise	14	14	14	15	15
Compr Str (flatwise), 1000 psi	34	25	32	25	37
Mod of Elast in Flex, 10^5 psi					
Lengthwise	14	9	13	11	10
Crosswise	11	7	10	8	8
Impact Str (edgewise), ft-lb/in.					
Lengthwise	0.55	0.55	0.5	0.6	1.3
Crosswise	0.50	0.50	0.45	0.5	1.2
Hardness (Rockwell)	M105	M100	M110	M112	M105
Bond Strength, psi	1100	—	1200	—	1800
ELECTRICAL PROPERTIES					
Dielec Str (perp, short time), v/mil					
1/16 In. Thick	700	700	650	650	500
1/8 In. Thick	500	500	470	470	360
Dielec Str (par., step by step, 1/8 in. thick), kv					
Cond A	50	65	65	65	50
Cond D48/50	10	15	15	33	6
Dissip Factor (10^6 cycles)					
Cond A	0.040	0.037	0.034	0.030	0.048
Cond D24/23	0.046	0.045	0.038	0.035	0.058
Dielec Const (10^6 cycles, cond A)	5.3	4.5	4.7	4.27	5.3
Insulation Res (cond C96/35/90), megohms	60	500	1000	20,000	30
Arc Resistance, sec	10	10	10	10	10
AIEE Insulation Class	A	A	A	A	A
USES	Panels for switchboards and instruments, switch and circuit breaker arms, terminal blocks for motors and transformers, coil forms for radio and television, brush holder bushings, bobbin heads and spools	Condenser stator brackets, wave change switch rotors and stators, plug and socket bases, terminal boards and subpanels, insulating washers	Panels for radio and television equipment; jack spacers, radio coil forms, high voltage switchgear	Condenser stator brackets, wavechange switch rotors and stators, terminal boards and subpanels, coil support bases	Terminal blocks and strips, panels, high humidity applications

High Pressure Laminates (Electrical)—concluded

Grade →	G-2 (glass cloth–phenolic)	G-6 (glass cloth–silicone)	G-7 (glass cloth–silicone)	N-1 (nylon fabric–phenolic)	Electrical Insulation Fibre
PHYSICAL PROPERTIES					
Density, gm/cu cm	—	1.65	1.68	1.15	1.15
Ther Cond, Btu/hr/sq ft/°F/ft	—	0.17	0.17	—	—
Max Rec Svc Temp, F					
Short Time	410	500	500	200	—
Continuous	290	400	400	165	—
Coef of Ther Exp, 10^{-5} per °F					
Lengthwise	—	0.31	—	—	—
Crosswise	—	0.31	—	—	—
Water Absorption (24 hr), %					
1/16 In. Thick	1.50	0.3	0.3	0.3	66
1/8 In. Thick	0.95	0.25	0.20	0.2	61
1/2 In. Thick	0.55	0.15	0.15	0.1	36
MECHANICAL PROPERTIES					
Ten Str, 1000 psi					
Lengthwise	16	13	23	8.5	7.5
Crosswise	11	10	18	8	5.5
Flex Str, 1000 psi					
Lengthwise	30	23	44	18	—
Crosswise	20	19	37	15	—
Compr Str (flatwise), 1000 psi	38	40	45	—	32
Mod of Elast in Flex, 10^5 psi					
Lengthwise	13	—	14	6	—
Crosswise	10	—	12	5	—
Impact Str (edgewise), ft-lb/in.					
Lengthwise	6.6	15.1	12.1	3.7	—
Crosswise	4.7	9.5	9.6	3.3	—
Hardness (Rockwell)	M110	M95	M100	M105	—
Bond Strength, psi	1400	1000	800	1200	—
ELECTRICAL PROPERTIES					
Dielec Str (perp, short time), v/mil					
1/16 In. Thick	500	250	400	600	175
1/8 In. Thick	425	185	350	450	175
Dielec Str (par., step by step, 1/8 in. thick), kv					
Cond A	30	50	55	62	—
Cond B48/50	10	45	30	55	—
Dissip Factor (10^6 cycles)					
Cond A	0.025	0.0022	0.0015	0.024	—
Cond D24/23	0.080	0.0227	0.0150	0.030	—
Dielec Const (10^6 cycles, cond A)	5.5	4.18	3.9	3.3	—
Insulation Res (cond C96/35/90), megohms	5000	4000	2500	5×10^4	—
Arc Resistance, sec	—	220	220	—	100
AIEE Insulation Class	B	H	H	A	A
USES	Class B insulation; other applications where good temperature resistance is required but mechanical properties are not critical	Insulation applications where high temperature resistance, arc resistance and low losses are needed, such as Class H transformers	Radio transmitter parts; Class H transformers; low loss, high frequency radio and radar insulators; motor slot wedges; slot liners; top sticks	High voltage applications; radio wave change switch stators and rotors, where low losses are critical; electrical insulating parts that must be postformed	Armature slot insulation, armature end laminations; field coil insulation, metal box liners, washers, arc shields, formed slot wedges, gaskets, specialties

Rubber

Type ➡	Natural Rubber	Butadiene-Styrene (GR-S)	Butadiene-Acrylonitrile (nitrile)	Chloroprene (neoprene)	Butyl (isobutylene-isoprene)
PHYSICAL PROPERTIES					
Specific Gravity	0.93	0.94	1.00	1.25	0.90
Ther Cond, Btu/hr/sq ft/°F/ft	0.082	0.143	0.143	0.112	0.053
Coef of Ther Exp (cubical), 10^{-5} per °F	37	37	39	34	32
Electrical Insulation	Good	Good	Poor	Fair	Good
Flame Resistance	Poor	Poor	Poor	Good	Poor
Min Rec Svc Temp, F	–60	–60	0	–40	0
Max Rec Svc Temp, F	180	180	250	240	210
MECHANICAL PROPERTIES					
Ten Str, psi					
Pure Gum	2500–3500	200–300	500–900	3000–4000	2500–3000
Black	3500–4500	2500–3500	3000–4500	3000–4000	2500–3000
Elongation, %					
Pure Gum	750–850	400–600	450–700	800–900	750–950
Black	550–650	500–600	450–650	500–600	650–850
Hardness (durometer)	A30–A90	A40–A90	A40–A95	A40–A95	A40–A75
Rebound					
Cold	Excellent	Good	Good	Very good	Bad
Hot	Excellent	Good	Good	Very good	Very good
Tear Resistance	Excellent	Fair	Good	Fair to good	Good
Abrasion Resistance	Excellent	Good to excellent	Good	Good	Fair
CHEMICAL RESISTANCE					
Sunlight Aging	Poor	Poor	Poor	Very good	Very good
Oxidation	Good	Good	Good	Excellent	Very good
Heat Aging	Good	Very good	Excellent	Excellent	Excellent
Solvents					
Aliphatic Hydrocarbons	Poor	Poor	Excellent	Good	Poor
Aromatic Hydrocarbons	Poor	Poor	Good	Fair	Poor
Oxygenated, Alcohols	Good	Good	Poor	Poor	Good
Oil, Gasoline	Poor	Poor	Excellent	Good	Poor
Animal, Vegetable Oils	Poor to good	Poor to good	Excellent	Good	Excellent
Acids					
Dilute	Fair to good	Fair to good	Good	Excellent	Excellent
Concentrated	Fair to good	Fair to good	Good	Good	Excellent
Permeability to Gases	Fair	Fair	Fair	Low	Very low
Water Swell Resistance	Fair	Excellent	Excellent	Fair	Excellent
USES	Pneumatic tires and tubes; power transmission belts and conveyor belts; gaskets; mountings; hose; chemical tank linings; printing press platens; sound or shock absorption; seals against air, moisture, sound and dirt		Carburetor diaphragms, self-sealing fuel tanks, aircraft hose, gaskets, gasoline and oil hose, cables, machinery mountings, printing rolls	Flexible petroleum tubes and hoses, petroleum and chemical tank linings; electrical insulation in contact with oil, flashlight cases, electrical sockets, special truck tires	Truck and automobile tire inner tubes, airing bags for tire vulcanization and molding, steam hose and diaphragms, flexible electrical insulation

Rubber—concluded

Type →	Polysulfide (Thiokol)	Silicone (polysiloxane)	Urethane (diisocyanate polyester)	Fluorinated Acrylic (dihydroperfluoro-butylacrylate)
PHYSICAL PROPERTIES				
Specific Gravity	1.35	1.25	1.25	1.5
Ther Cond, Btu/hr/sq ft/°F/ft	—	67	—	—
Coef of Ther Exp (cubical), 10^{-5} per °F	—	67	—	—
Electrical Insulation	Fair	Good	Good	Good
Flame Resistance	Poor	Fair	Good	Good
Min Rec Svc Temp, F	−60	−120	−65	0
Max Rec Svc Temp, F	250	550	240	450
MECHANICAL PROPERTIES				
Ten Str, psi				
Pure Gum	>1000	600–1000	>5000	1200
Black	—	—	—	—
Elongation, %				
Pure Gum	450–650	60–400	540–750	300
Black	—	—	—	300
Hardness (durometer)	A40–A85	A40–A85	A35–A100	A55
Rebound				
Cold	Good	Excellent	Bad	—
Hot	Good	Excellent	Good	—
Tear Resistance	Poor	Poor	Good	Poor
Abrasion Resistance	Poor	Poor	Excellent	Poor
CHEMICAL RESISTANCE				
Sunlight Aging	Very good	Excellent	Excellent[a]	Good
Oxidation	Very good	Very good	Very good	Good
Heat Aging	Fair	Outstanding	Excellent[a]	Good
Solvents				
Aliphatic Hydrocarbons	Excellent	Poor	Excellent	Excellent
Aromatic Hydrocarbons	Excellent	Poor	Excellent[b]	Excellent
Oxygenated, Alcohols	Very good	Fair	Poor	Good
Oil, Gasoline	Excellent	Fair	Excellent	Excellent
Animal, Vegetable Oils	Excellent	Excellent	Excellent	Excellent
Acids				
Dilute	Good	Excellent	Fair	Excellent[c]
Concentrated	Good	Fair	Poor	Excellent[d]
Permeability to Gases	Extremely low	Fair	Excellent	Fair
Water Swell Resistance	Excellent	Excellent	Excellent	Poor
USES	Seals, gaskets, diaphragms, valve seat disks, flexible mountings, hose in contact with solvents, balloons, boats, life vests and rafts	Wire and cable covering, gaskets, tubing, diaphragms, vibration mountings, rollers, insulators, valve seats and closures	Fork lift truck wheels, airplane tail wheels, back-up wheels for turbine blade grinders, spinning cots for glass fiber, hydraulic accumulators, shoe heels	O-rings; V-rings; diaphragms; special applications involving contact with halogenated solvents, organic phosphates and carbon tetrachloride

[a]Discolors, but no change in properties.
[b]For up to 80% aromatics.
[c]To diesters, 450 F.
[d]To fire resistant hydraulic fluids, 450 F.

Hard Rubber

Type →	Molded Parts[a]								
	GP	GP	GP	GP	H Ht	H Ar	Ar Ht Wr, H DQ	H Ht, Ch	Ht Ma
PHYSICAL PROPERTIES[b]									
Specific Gravity	1.21	1.21	1.28	1.54	1.65	1.95	1.71	1.24	1.80
Water Absorption (24 hr), %	0.08	0.06	0.14	0.30	0.06	0.06	0.10	0.12	0.04
Color	Black	Black	Black	Black	Red-brown	Red-brown	Red-brown	Black	Black
MECHANICAL PROPERTIES									
Ten Str, 1000 psi	8.3	7.9	4.5	2	6.75	4	5.8	7.17	5.4
Elong (in 2 in.), %	4.00	4.00	3.40	2.00	2.60	1.00	2.60	2.70	1.80
Hardness (Rockwell)	B108–76	B107–91	B129–79	B103–27	B83–60	B65–41	B82–55	B115–85	B82–54
Hardness (durometer)	81–87	81–87	78–84	76–82	85–92	87–95	86–92	84–90	84–92
Impact Str (Izod notched), ft-lb/in.	0.48	0.45	0.45	0.27	0.35	0.32	0.38	0.41	0.34
Flex Str, 1000 psi	12.5	11.3	7.1	2.8	8.7	8.4	9.1	11.3	10
Heat Dist Temp, F	142	145	134	Low	283	300	246	275	295
ELECTRICAL PROPERTIES									
Dielec Str (60 cycles), v/mil	435	496	344	377	393	600	371	400	420
Dielec Const[c]	3.00	2.95	3.80	4.95	4.10	4.80	4.60	3.50	4.10
Dissip Factor[c]	0.8	0.7	1.2	2.8	1.2	2.5	1.2	1.6	1.8
Surface Res (74 F, 86% RH), megohms	4.8×10^5	$>10^8$	$>10^8$	5.08×10^5	5.32×10^5	—	4.46×10^4	2.0×10^3	8.02×10^6

Type →	Sheets[a]					Rods and Tubes[a]			
	GP	El[d]	H Ht	H Ht, Ch	St Fl, H DQ	GP	El	H Ht, Ch	St Fl, H DQ
PHYSICAL PROPERTIES[b]									
Specific Gravity	1.20	1.17	1.43	1.24	1.27	1.21	1.15	1.24	1.27
Water Absorption (24 hr), %	0.06	0.22	0.15	0.12	0.08	0.06	0.12	0.12	0.07
Color	Black	Black	Black	Black	Yellow-brown	Black	Black	Black	Yellow-brown
MECHANICAL PROPERTIES									
Ten Str, 1000 psi	9.3	2.55	7.4	7.17	7.45	9.7	3.6	7.17	6.5
Elong (in 2 in.), %	5.00	33.00	1.20	2.70	5.30	5.00	16.00	2.70	3.80
Hardness (Rockwell)	112–79	—	86–60	115–85	112–80	107–70	—	115–85	112–80
Hardness (durometer)	80–86	50–60	86–92	84–90	80–86	80–86	65–75	84–90	80–86
Impact Str (Izod notched), ft-lb/in.	0.48	0.51	0.53	0.41	0.50	0.48	0.48	0.41	0.52
Flex Str, 1000 psi	16.6	—	9.64	11.3	14.95	11.375	—	11.3	9.06
Heat Dist Temp, F	159	Low	221	275	150	163	Low	275	217
ELECTRICAL PROPERTIES									
Dielec Str (60 cycles), v/mil	487	437	613	400	415	524	512	400	374
Dielec Const[c]	2.95	3.00	3.25	3.50	3.70	2.90	3.15	3.50	3.60
Dissip Factor[c]	0.5	1.3	0.6	1.6	0.6	0.5	1.4	1.6	0.9
Surface Res (74 F, 86% RH), megohms	2.23×10^7	2.66×10^4	$> 10^8$	2.0×10^3	7.98×10^4	$> 10^8$	$> 10^8$	2.0×10^3	6.73×10^4

[a]GP = general purpose, H = high, HT = heat resistance, Ar = arc resistance, Wr = wear resistance, DQ = dielectric quality, Ch = chemical resistance, MA = low moisture absorption, El = elongation, St = strength, Fl = flow resistance. These designations are arbitrary abbreviations of principal properties and are not standard.

[b]Hard rubber in general has a thermal coefficient of linear expansion of 0.00004 per °F.

[c]Frequency: 1 kc-1 mc.

[d]Semihard.

Flexible Foams

LATEX

Density, lb/cu ft	6.0–7.0
Ther Cond, Btu/hr/sq ft/°F/ft	0.021–0.025
Tensile Strength, psi	10–20
Max Rec Svc Temp, F	160
Flammability	Burns
Tear Strength, lb/in.	1.2
Resilience, %	64
Rebound, in.	2.5
Elongation, %	380
Compression Loss, %	
50,000 Flexes	13.0
300,000 Flexes	15.0
Compression Set, %	
22 Hr at 158 F	4.6
22 Hr at 177 F	4.1
Hysteresis Loss, %	23.2
RMA Compression, lb	30.0

POLYETHYLENE (CELLULAR)[a]

Tensile Strength	670
Elongation, %	310
Specific Gravity	0.47
Dielectric Strength, v/mil	
Short Time	220
Long Time	190
Dissipation Factor	
1000 Cycles	0.00033
10,000 Cycles	0.00038
Dielectric Constant	
1000 Cycles	1.48
10,000 Cycles	1.49

[a]Wire insulation for No. 14 AWG (0.250-in. o. d.). Wire insulation is the primary use of cellular polyethylene at present.

VINYL (OPEN CELL)

Density, lb/cu ft	4 and up
Heat Sealability	Excellent
Tensile Strength, psi	10–200
Elongation, %	75–300
Flammability	Self-extinguishing
Indentation Load	
Deflection (25% def)	
Original, lb/50 sq in.	3–500
After Aging, % chg[a]	±20
Compression Set (max, 2 hr at 158 F), %	15
Set after Dynamic Flexing (max, 250,000 cycles), %	10
Chemical Resistance[b]	
Strong Acids	E
Strong Alkalis	E
Grease, Oils	G
Organic Solvents	P to E
Water	E
High Humidity	E
Sunlight	G

[a]Air oven aging 22 hr, 212 F.
[b]E = excellent; G = good; P = poor.

SYNTHETIC RUBBERS

Type →	Neoprene	Butadiene-Styrene (GR-S)	Butadiene-Acrylonitrile
Density, lb/cu ft	10–30	4.5	10–25
Ther Cond, Btu/hr/sq ft/°F/ft	0.021–0.029	0.018	0.021–0.025
Tensile Strength, psi	20–100	80	40
Max Rec Svc Temp, F	180	160	210

URETHANES

Density[a] →	1	2-4	6-8	10-12	16-20
Yld Str (0.2% offset), psi	2.5	4–20	50–75	200	—
Compr Str (50% defl), psi	5	9–48	78–150	200–380	—
Coef of Ther Exp (−22 to 86 F)					
10^{-5} per °F	—	1.4	—	—	5
Ther Insulation Coef (K)	0.20	0.20–0.21	0.22–0.23	0.26	0.28–0.30
Water Absorption, lb/cu ft					
25-Day Soak	28	22.8–24	—	—	2–4
120 Hr at 50% RH	0.005	0.006–0.027	—	—	0.067–0.084
120 Hr at 98% RH	0.38	0.38–0.39	—	—	0.359–0.560
Dielec Const (1000 cycles)	—	2.2–2.3	—	2.5	2.70–2.85
Vol Res, 10^{14} ohm-cm	—	6.8–6.9	—	7.2	7.7–8.3
Sound Absorption Coef					
250 Cycles	—	0.73	0.20	0.22	—
500 Cycles	—	0.33	0.22	0.21	—
1000 Cycles	—	0.37	0.20	0.31	—
Bond Str, psi					
Aluminum	6	10–27	—	56	158
Glass	5	9–25	—	50	142
Steel	7	12–29	—	62	146
Wood	8	17–29	—	62	170
Flame Res[b]					
2 Lb/Cu Ft	Incombustible				
10 Lb/Cu Ft	Self-extinguishing				
Max Rec Svc Temp, F	200				
Heat Dist Temp (5 psi flex, 0.10 in. defl), F	130				
Chemical Res	Swell slightly in many chemical solutions. Attacked by strong acids and alkalis				

[a]Density in lb per cu ft.
[b]Federal Bldg Spec SSA118A.

Foamed-in-Place Foams

EPOXIES, PHENOLICS AND URETHANES

Type and Density[a] →	Epoxy		Phenolic		Urethane			
	25-28	39	2-5	7-10	0.5-5	6-9	12-15	18-25
Compr Str, psi	1000	—	9–31	45–130	5–30	150–225	350–600	800–1200
Ten Str, psi	900	—	4–35	35-75	10–50	150–250	305–400	450–1000
Flex Str, psi	—	4200	24–40	75–230	—	—	—	—
Shear Str, psi	—	—	8–30	40–135	2–50	50–120	180–250	>250
Ther Cond, Btu/hr/sq ft/°F/ft	—	0.067	0.020	0.023	0.02–0.03	0.02–0.03	0.02–0.03	0.02–0.03
Coef of Ther Exp, 10^{-5}, per °F	4.0	1.05	—	—	1.5	2.9	4.4	—
Mod of Elast in Tension, psi	60,000	—	—	—	—	—	—	—
Water Abs (vol), %	—	0.1	—	—	—	1.6	0.6	0.2
Water Abs (wt), %								
100% RH	—	—	13–51	10–51	—	—	—	—
50% RH	—	—	1–4	1–5	—	—	—	—
20% RH	—	—	½–1	1–2	—	—	—	—
Max Rec Svc Temp, F	—	—	300[b]	300[b]	250	250	250	300
Flammability	—	—	Nonflammable		Self-extinguishing			
Impact Str (unnotched), in.-lb	—	—	—	—	—	—	—	—
Dissip Factor	0.01–0.03	0.015	—	—	0.0005	0.001	0.002	0.003
Vol Res, ohm-cm	—	10^{13}	—	—	—	—	—	—
Dielec Str, v/mil	—	300	—	—	—	—	—	—
Dielec Const	2.0–6.0	1.9	—	—	1.05	1.15	1.25	1.40

[a]Density in lb per cu ft. [b]For intermittent exposure: 550 F.

SILICONES

Density[a] →	12[b]	14[b]
Compr Str (orig), psi	100	200
Compr Str (after aging), psi[c]		
77 F, 200 Hr	100	190
500 F, ½ Hr	5	25
500 F, 200 Hr	20	45
Weight Loss During Expansion, %	1.2	1.3
Weight Loss After Heating, %		
1000 Hr, 500 F	2.5	2.6
1000 Hr, 570 F	8.0	4.2
72 Hr, 700 F	8.5	5.2
Water Abs (24 hr), %	3.2	2.3
Heat Dist Temp, F	>700	>700
Flammability	No burn	No burn
Dielec Const (10^5 cycles)	1.23	1.25
Dissip Factor (10^5 cycles)	0.0004	0.00102
Ther Cond, Btu/hr/sq ft/°F/ft	0.025	0.025

[a]Density in lb per cu ft.
[b]Expanded at 320 F.
[c]Tested at 500 F.

POLYSTYRENES

Density[a] →	2	3	4	6	8	10
Ten Str, psi	30–50	55–75	65–85	90–110	110–120	120–130
Compr Str (5% offset), psi	15–20	25–35	40–50	60–70	70–80	90–100
Flex Str, psi	Flexible	60–90	90–120	130–160	200–230	280–310
Impact Str (unnotched), in.-lb/in.[b]	2.0–2.5	2.3–2.8	2.5–3.0	3.0–3.5	4.3–4.8	5.0–5.5
Ther Cond, Btu/hr/sq ft/°F/ft	0.0183	0.0188	0.0192	0.0203	0.0215	0.0225
Max Rec Svc Temp, F	185	185	185	185	185	185

Density 2-10[a]	Density 4-6[a]
Dissip Factor >0.0005	Dielec Const (73 F, 50% RH)
Loss Factor >0.0006	60 Cycles 1.19
Vol Res, 10^7 megohm-cm >3.81	10^6 Cycles 1.02
Surface Res, 10^6 megohms >9.8	Dielec Const (48 hr, 122 F)
Dielec Str, v/mil	60 Cycles 1.24
Short Time 48	10^6 Cycles 1.05
Step by Step 49	Dielec Const (96 hr, 95 F, 96% RH)
	60 Cycles 1.24
	10^6 Cycles 1.05

[a]Density in lb per in. ft.
[b]1-in. wide specimen.

Prefoamed Foams

POLYSTYRENES AND CELLULOSE ACETATE

Type and Density[a] →	Polystyrene				Cellulose Acetate (cellular)		
	1.3	1.6	2.0	3.0-4.2	4	6-7	7-8
Compr Yld Str, psi	10–20	15–25	25–35	50–140	128	197	235
Ten Str, psi	30–45	50–70	80–100	105–185	112	158	183
Shear Str, psi	15–25	25–35	35–45	55–95	100	140	185
Flex Str, psi	>32	—	—	<170	73	147	177
Compr Mod of Elast, 1000 psi	0.45–1.1	0.75–1.35	1.15–1.75	1.7–5.3	5.5	7.0	13.5
Flex Mod of Elast, 1000 psi	0.20–0.75	0.65–1.2	1.2–1.9	—	3.5	5.5	—
Impact Str, psi	0.5–1.2	1.1–1.8	2.1–2.7	—	—	0.01	1.15
Flammability, ipm	Self-extinguishing types available				8.5	4.9	4.2
Ther Cond, Btu/hr/sq ft/°F/ft	0.020–0.024				0.025	0.026	0.027
Coef of Ther Exp, per °F	$2–5 \times 10^{-5}$				$2.0–2.5 \times 10^{-5}$		
Spec Ht, Btu/lb/°F	0.27				—		
Max Rec Svc Temp, F	155–165				200–350		
Water Absorption (vol), %	<6				0.15, 1.05[b]		
Water Vapor Transmission[c]	1.5–3.0				—		
Dielec Const	<1.07				1.10–1.12		
Dissip Factor	<0.0004				0.002–0.003		

[a]Density in lb per cu ft. [b]Absorption in lb per cu ft at 50 and 100% RH, respectively. [c]Grains/sq ft/hr/in. Hg.

UREA

Density, lb/cu ft	0.8–1.2
Compr Yld Str, psi	200
Ther Cond, Btu/hr/sq ft/°F/ft	0.015–0.018
Max Rec Svc Temp, F	200

SILICONE

Density, lb/cu ft	16[a]
Ther Cond, Btu/hr/sq ft/°F/ft	0.025
Water Abs (vol), %	2.1
Dielec Const	1.26
Dissip Factor	0.00105
Flammability	Nonflammable
Heat Dist Temp F	>700
Compr Str (orig), psi	325
Compr Str (after aging), psi[b]	
77 F, 200 Hr	210
500 F, ½ Hr	70
500 F, 200 Hr	80
Weight Loss During Expansion, %	1.0
Weight Loss After Heating, %	
1000 Hr, 500 F	2.6
1000 Hr, 570 F	4.2
72 Hr, 700 F	5.2

[a]Expanded at 320 F.
[b]Tested at 500 F.

EPOXIES AND MIXED COPOLYMER

Type and Density[a] →	Expanded Mixed Copolymer[b]	Epoxy			
		3	10	25	38
Compr Yld Str, psi	45–90	65	340	1200	6000
Ten Str, psi	120–350	55	320	1100	—
Flex Str, psi	—	—	—	—	4500
Compr Mod of Elast, 1000 psi	—	—	11	52	—
Flex Mod of Elast, 1000 psi	11.6	—	—	—	—
Ther Cond, Btu/hr/sq ft/°F/ft	0.022–0.029	0.014	0.020	—	0.054
Coef of Ther Exp, 10^{-5} per °F	3.4–4.0	—	2.2	—	1.6
Max Rec Svc Temp, F	—	300	300	300	350
Water Abs (vol), %	0.05–0.10	1.3	0.25	0.1	0.09
Dielec Const	1.14–1.18	1.04	1.18	1.47	1.9
Dissip Factor	0.14–0.18	<0.0001	0.0004	0.003	0.009

[a]Density in lb per cu ft.
[b]Styrene-acrylonitrile resin and butadiene-acrylonitrile rubber.

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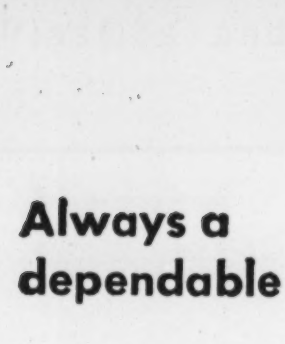

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VINYLITE	√	√	√				
ACETATE	√	√	√	√			
POLYSTYRENE	√	√	√			√	√
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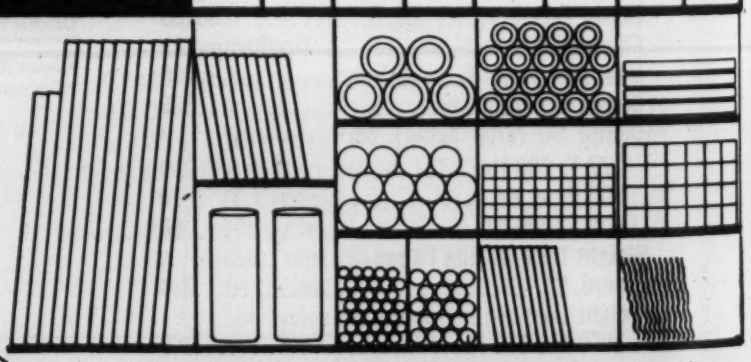

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Good Dielectric Strength
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Durable
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EASILY FABRICATED

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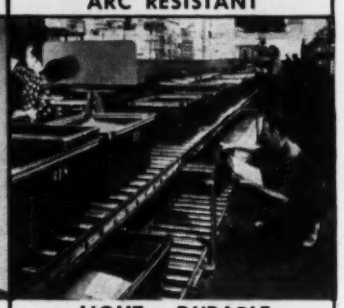

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Resiliency
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Moisture Resistance
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Wear Resistance
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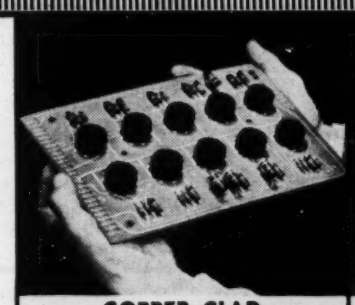
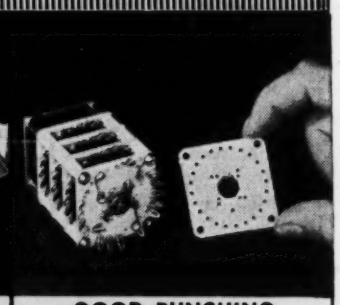
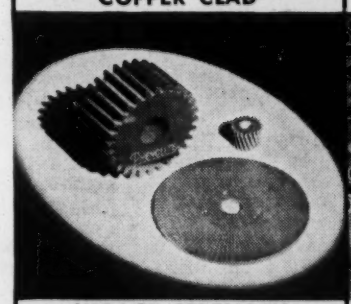


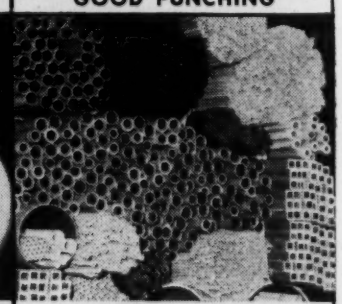
COPPER CLAD



GOOD PUNCHING



IMPACT STRENGTH



RODS — TUBES

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SUPPLIERS' LITERATURE

Nonmetallics
(except Plastics and Rubber)

Dacron Felt. American Felt Co., 4 pp. Cold and heat resistance, compression set, weight, breaking strength and splitting resistance of Dacron felt for seals, gaskets and cushions. **166**

Ceramics. Steatite Div., American Lava Corp., 4 pp, illus., No. 563. Mechanical and electrical properties of AlSiMag ceramics. **167**

Silicon Carbide. Carborundum Co., 8 pp, illus., No. 1. "Advanced Materials Technology" contains information on a self-bonded silicon carbide for high temperatures. **168**

Flocked Paper. Cellusuede Products, Inc., illus. Sample kit containing actual swatches of colored flocked paper. Gives suggestions for cutting, folding and printing the flocked paper. **169**

Glass Fabrics. Coast Mfg. & Supply Co., 20 pp. illus. Describes a line of glass fabrics and discusses resin systems for impregnating fabrics and papers. **170**

Felt. Continental Felt Co., Inc., 10 pp, illus. A history of felt and a description of some of its uses in machinery and industrial products. **171**

Alumina Ceramic. Coors Porcelain Co., 4 pp, illus. Mechanical and electrical properties, dimensions and uses of parts made from a dense, nonporous, 99% aluminum oxide ceramic. **172**

Glass. Corning Glass Works, 16 pp, illus., No. B-83. Mechanical, thermal, electrical and chemical properties of alumino-silicate glass and radiotron tube and capacitor glass. **173**

High Alumina Ceramics. Diamonite Products Mfg. Co., 2 pp, illus. Properties and uses of standard and special high alumina ceramic products. **174**

Fir Plywood. Douglas Fir Plywood Assn., 18 pp, illus. Types and grades, acoustical and thermal properties, and design data on Douglas fir plywood. **175**

Silicone Products. Dow Corning Corp., 16 pp, illus. Properties and uses of over 150 commercially available silicone products. **176**

Synthetic Fibers. E. I. du Pont de Nemours & Co., Inc., Textile Fibers Dept., Wilmington 98, Del., 76 pp, illus. Performance of synthetic fibers in such industrial applications as hose, belting, filters, packings, reinforced plastics and specialty papers. Write on company letterhead directly to Du Pont.

Fused Silica, Quartz. Amersil Co., Inc., Div. of Engelhard Industries, 10 pp, illus. Mechanical and electrical properties, uses, heat resistance, handling information and optical properties for fused quartz and silica. **177**

Impregnated Felt. Felters Co., 4 pp, illus. Properties and uses for a thermoplastic resin-impregnated felt that can be electronically stitched and heat sealed. **178**

Wood Sheets. Fibron Products, Inc., 4 pp. Properties and uses of a wood sheet material called "Stamina" wood. **179**

Friction or Damper Parts. World Bestos Div., Firestone Tire & Rubber Co., 4 pp, illus., No. 648. Available molded parts—brake linings and blocks, transmission linings, clutch facings and thrust washers. **180**

Carbide Parts. Firth Sterling, Inc., 2 pp, illus. Uses, physical properties, and brazing and grinding of a general purpose carbide. **181**

Reinforced Wood. Gamble Bros., Inc., 4 pp. Explains why wood reinforced with a high strength thermoplastic resin has increased impact resistance and increased durability. **182**

Silicone Products. General Electric Co., Silicone Products Dept., 8 pp, illus., No. CDS-129. Properties and uses of silicone rubber, fluids, resins, water repellents, electrical insulation, lubricants and paint vehicles. **183**

Plastic-Faced Plywood. Georgia-Pacific Co., 14 pp, illus. Advantages of GPX plastic-faced plywood used for cabinets and industrial counters. **184**

Ceramic Materials. Globe-Union Inc., Centralab Div., 16 pp, illus. Design information, properties, specifications and uses of engineered ceramics. **185**

Graphite. Graphite Specialties Corp., 4 pp., No. GS-101-1. Chemical and physical properties of an impervious graphite for high temperature parts. **186**

Glass Fiber Insulation. Gustin-Bacon Mfg. Co., 6 pp, illus. Physical properties, thermal conductivity, handling characteristics and acoustical efficiency of an insulation made of blown glass fibers. **187**

Electrical Insulation. Johns-Manville Corp., 2 pp. Thermal stability, dielectric strength, mechanical and chemical properties, and electrical properties after aging of a silicone-asbestos electrical insulation. **188**

Titanium Carbides. Kennametal, Inc., 12 pp, illus., No. B-444. Shows titanium carbide parts that have been used at temperatures above 1800 F. Physical properties and corrosion resistance are given for 13 different compositions. **189**

Specialty Papers. Knowlton Brothers, Inc., Watertown, N. Y., 12 pp, illus. Specialty papers for facsimile transmission and radio and TV speakers. Write on company letterhead directly to Knowlton.

Glass Fiber Insulation. L. O. F. Glass Fibers Co., 4 pp, illus. Insulation efficiency, uses, vibration and airflow resistance, compressibility, dimensional data and tensile strength of quartz and glass fiber thermal insulations. **190**

Glass Products. Lancaster Glass Corp., 28 pp, illus. Case histories on the use of glass in television tubes, auto dome lights, desk sets, refrigerator lights and vending machines. **191**

Industrial Ceramics. McDanel Refractory Porcelain Co., 16 pp, illus., No. P 258R. Dimensional data, and physical, thermal and electrical properties of ceramic tubing, insulators and custom shapes. **192**

Tungsten Carbide. Metal Carbides Corp., 24 pp, illus. Information on tungsten carbide products produced by both hot and cold pressed methods. Shows company facilities. **193**

Mica Insulation. Mica Insulator Div., Minnesota Mining & Mfg. Co., 20 pp, illus. Thicknesses and dielectric strengths of mica rings, tubes, plates, sheets and tapes available for Class B, H and C electrical insulations. **194**

Paper Products. Mosinee Paper Mills Co., 3 pp, illus. Outlines uses and advantages of a flame resistant paper. Gives average physical properties of flat and creped neutral papers. **195**

Glass-Bonded Mica. Mycalex Corp. of America, 24 pp, illus. Physical, electrical and thermal properties, and dimensional tolerances of ceramo-plastics and glass-bonded micas. **196**

Thermal Insulation. Norton Co., Refractories Div., 6 pp, illus., No. CP8.4.2. Composition, electrical properties, grain size and uses for an electrical grade thermal insulation made of fused magnesium oxide. **197**

Electrical Insulation. Owens-Corning Fiberglas Corp., Electrical Div., 598 Madison Ave., New York 22. Chemical resistance, design information, application data and uses for fiberglass cordage and sealing thread used in electrical insulations. Write on company letterhead directly to Owens-Corning.

Glass Fiber Insulation. Pittsburgh Plate Glass Co., Fiber Glass Div., 4 pp, illus. Advantages of glass fibers for sound and heat insulation applications. **198**

Carbon Graphite. Pure Carbon Co., Inc., 12 pp, illus., No. 55. Characteristics, grades and suggested uses for carbon graphite. **199**

Ceramic Magnets. Stackpole Carbon Co., 12 pp, illus., No. RC-11A. Magnetic properties and uses of high coercive force permanent ceramic magnets. **200**

Industrial Ceramics. Star Porcelain Co., 20 pp, illus., No. 57. Descriptive and engineering data on commercial white porcelain, Nu-Blac, Thermolain, Steatite, Vitrolain, Humidolain, Lavolain, and 5606 Refractory materials. **201**

Thermal Insulation. H. I. Thompson Fiber Glass Co., chart. Information on thermal insulations for temperatures from —300 F to 3000 F. **202**

Impervious Graphite. National Carbon Co., Div. of Union Carbide Corp., 4 pp, No. S-5050. Procedures for applying "Karbate" impervious graphite and "National" resin-base cements to parts used in corrosive service. **203**

Silicone Compounds. Union Carbide Corp., Silicones Div., 8 pp, illus., No. SP-1010A. Uses and properties of organo-silicone polymers with unusual lubricating and solubility properties. **204**

High Temperature Ceramics. Alite Div., U. S. Stoneware Co., 7 pp, No. A-7. Physical and high temperature properties, methods of joining and electrical characteristics of Alite, a sintered aluminum oxide used in high temperature applications. **205**

Felt. Western Felt Works, 28 pp. Discussion of felt: its applications, composition, specifications and testing methods. **206**

Insulating Materials. Westinghouse Electric Corp., illus., No. B-7206. Types, characteristics and applications of Class A shellac and varnish-coated papers and organic-varnished glass. **207**

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PROPERTIES OF MATERIALS

Nonmetallics

(except Plastics and Rubber)

	PAGE
Mechanical and Electrical Ceramics	228
Mica	230
Refractory Ceramics and Cermets	231
Glass (Industrial)	234
Carbon and Graphite	236
Mineral Fibers	237
Synthetic Fibers	238
Natural Fibers	240
Woods and Composition Board	241
Mechanical Felts	242
Advertisements	244
Suppliers' Literature	226

Mechanical and Electrical Ceramics[a]

Type →	Polycrystalline Glass (Pyroceram) 9606[b]	Polycrystalline Glass (Pyroceram) 9608[b]	Cordierite	Forsterite
PHYSICAL PROPERTIES				
Specific Gravity	2.60	2.50	2.29–2.65	2.9
Ther Cond, Btu/hr/sq ft/°F/ft	2.10	1.14	0.97–2.40	1.94–2.40
Coef of Ther Exp, per °F				
68–212 F	5.7×10^{-6}	$0.7–2.0 \times 10^{-6}$[c]	2.08×10^{-6}	4.72×10^{-6}
68–932 F	—	—	1.68×10^{-6}	5.40×10^{-6}
Thermal Shock Resistance	Good	Good	Good	Moderate
Water Absorption, %	0.00	0.00	0.02–3.2	0.00–0.02
Gas Permeability	Gas-tight	Gas-tight	—	Gas-tight
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	17.3×10^6	12.5×10^6	7×10^6	—
Mod of Rupture, 1000 psi	20	16–23	6.8	19
Tensile Strength, 1000 psi	—	—	3.0	10
Hardness (Knoop)	698[d]	703[d]	7	7.5
Impact Strength (Charpy), in.-lb				
¾ In. Dia	—	—	7.4	7.5
½ In. Dia	—	—	4.4	2.4–4.0
Flexural Strength, 1000 psi	—	—	15	20
Compressive Strength, 1000 psi	—	—	52–95	80–85
ELECTRICAL PROPERTIES				
Volume Resistivity, ohms/cu cm				
68–77 F	—	—	$>10^{14}$	$>10^{14}$
212 F	—	—	—	5.0×10^{13}
482 F	10^{10}	10^{10}	—	—
572 F	—	—	—	7.0×10^{11}
662 F	4×10^8	4×10^8	—	—
932 F	—	—	—	1.2×10^{10}
1292 F	—	—	—	1.0×10^8
1652 F	—	—	—	3.0×10^6
Dielectric Strength, v/mil	—	—	140–230	250
Dielectric Constant				
60 Cycles	—	—	—	6.3
1 Mc	5.58	6.78	4.02–6.23	6.2–6.5
100 Mc	—	—	—	6.1
10,000 Mc	5.45	—	—	5.8
Dissipation Factor				
60 Cycles	—	—	—	0.0014
1 Mc	0.0015	0.0030	0.0010–0.00930	0.0002–0.0004
100 Mc	—	—	—	0.0003
10,000 Mc	0.00033	—	—	0.0010
Loss Factor				
60 Cycles	—	—	—	0.009
1 Mc	0.009	—	0.0297–0.0579	0.001–0.002
100 Mc	—	—	—	0.002
10,000 Mc	0.002	—	—	0.0058
Te Value, F[e]	—	—	1436	680–>1832
Temp Coef of Capacitance Chg[f]	—	—	420	—
HEAT RESISTANCE				
Max Rec Svc Temp, F	—	—	—	1832
Softening Temp, F	1250	1250	—	—
USES	Developed for uniform electrical properties in missile radomes. Other uses: electronic equip., abrasive binder, bearing parts, structural parts in hypersonic aircraft, air compressor blades	General purpose; laboratory equip., pump parts, pipe caps, thread guides, replacement for steel bearings, heat exchange tubes (under test), brake shoes, aircraft structural parts	Aircraft firewall connectors, appliance coil supports and terminal blocks, automotive heater cores, hot point insulators, brazing fixture parts, foundry parts, fuel burner tips, thermostat controls	Very low loss insulators, ceramic-to-metal seals (close tolerances obtainable by grinding)

[a] Alumina properties are on "Refractories" pages. [b] Manufacturer's designations for opaque grades; transparent grades are available.
[c] 77–572 F. [d] Knoop hardness at 100 gm.
[e] Te value is the temperature at which a cubic centimeter of the material has a resistance of 1 megohm. [f] 77–185 F, parts per million.

Mechanical and Electrical Ceramics—concluded

Type ➡	Standard Electrical	Steatite	Zircon
PHYSICAL PROPERTIES			
Specific Gravity	2.37–2.53	2.5–2.92	3.43–3.86
Ther Cond, Btu/hr/sq ft/°F/ft	0.87–1.57	1.45–1.94	2.88–3.61
Coef of Ther Exp, per °F			
68–212 F	2.00×10^{-6}	$3.33–3.99 \times 10^{-6}$	$1.31–1.84 \times 10^{-6}$
68–932 F	2.70×10^{-6}	$4.52–5.50 \times 10^{-6}$	$2.09–2.16 \times 10^{-6}$
Thermal Shock Resistance	Fair	Moderate	Good
Water Absorption, %	0.0–0.1	0.0–1.0	0.0–9.0
Gas Permeability	Gas-tight	—	—
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	10×10^6	$13–16 \times 10^6$	21×10^6
Mod of Rupture, 1000 psi	11	19–22	9–24
Tensile Strength, 1000 psi	2.5–7.0	4.8–15	4.5–12
Hardness (Mohs)	7.0–7.5	7.5	8
Impact Strength (Charpy), in.-lb			
¾ In. Dia	8.2	10.5–14.0	8.9–11.4
½ In. Dia	—	3.8–5.0	5.50–5.64
Flexural Strength, 1000 psi	5.4–12.0	11–20	18.5–22.0
Compressive Strength, 1000 psi	49.1–70.0	66–90	60–100
Transverse Strength, 1000 psi	11	—	—
ELECTRICAL PROPERTIES			
Volume Resistivity, ohms/cu cm			
68–77 F	$10^{13}–10^{15}$	$>10^{14}$	$>10^{14}$
212 F	1.2×10^8 [c]	$0.21–>100 \times 10^{13}$	2.0×10^{13}
570 F	5.0×10^6	$0.6–800 \times 10^8$	5.5×10^{11}
930 F	4.0×10^5 [d]	$0.32–300 \times 10^6$	5.5×10^8
1290 F	—	$2.3–500 \times 10^6$	1.4×10^7
1650 F	—	$7.0–680 \times 10^3$	8.2×10^5
Dielectric Strength, v/mil	55–300	145–280	60–290
Dielectric Constant			
60 Cycles	5.4–7.0	5.9–6.3	9.1
1 Mc	—	5.5–6.51	5.30–9.20
100 Mc	—	5.6–6.0	8.6
10,000 Mc	—	5.3–5.8	8.4
Dissipation Factor			
60 Cycles	0.0090–0.0112	0.0013–0.0150	0.0360
1 Mc	—	0.0011–0.0075	0.0007–0.0022
100 Mc	—	0.0009–0.0028	0.0012
10,000 Mc	—	0.0014–0.0054	0.0027
Loss Factor			
60 Cycles	0.053–0.060	0.008–0.090	0.327
1 Mc	—	0.007–0.0252	0.0041–0.0135
100 Mc	—	0.005–0.016	0.010
10,000 Mc	—	0.008–0.030	0.023
Te Value, F [a]	680–842	824–1544	1292–1598
Temp Coef of Capacitance Chg [b]	630	120	175
HEAT RESISTANCE			
Max Rec Svc Temp, F	1820	1832	2012
USES	Low voltage insulators, vitrified high voltage insulators, wire supports, outlet boxes, lightning arrestors, suspension insulators, x-ray rods and tubes	Aircraft insulators, appliance housings, electric line insulators, tube sockets, electrical instrument spacers and feedthrough bushings, fuel igniters, camera and projector rollers, thermostat controls	Aircraft firewall connector plugs and glow plugs; electronic tube sockets, coil forms, spacers, brackets, printed circuits and plates; pump valves, plungers and seats

[a] Te value is the temperature at which a cubic centimeter of the material has a resistance of 1 megohm.
[b] 77-185 F, parts per million. [c] 392 F [d] 752 F

Mica

Type →	Natural Muscovite	Synthetic Fluor-Phlogopite	Glass-Bonded Synthetic[a]	
			Insulation	Capacitor
PHYSICAL PROPERTIES				
Specific Gravity	2.6–3.2	2.9	3.0, 2.6–3.8	3.25, 3.5–3.8
Ther Cond, Btu/hr/sq ft/°F/ft	0.25–0.36	0.3–0.4	0.29, 0.23–0.31	—
Coef of Ther Exp, per °F	1.8×10^{-5}	$1.44–2.70 \times 10^{-5}$	$1.8, 1.8–2.0 \times 10^{-5}$	$1.8, 1.8–2.0 \times 10^{-5}$
Spec Ht, Btu/lb/°F	0.20	0.25	0.16, 0.13–0.24	—
Water Absorption	Low	Low	Nil	Nil
MECHANICAL PROPERTIES				
Mod of Elast in Tension, psi	$20–30 \times 10^6$	25×10^6	$9–12, 7–8 \times 10^6$	$9–12, 7–8 \times 10^6$
Ten Str, 1000 psi	40–50	45–55	6–7, 5–6	6, 5
Hardness				
Knoop	90	200	M110–120,[b] M115–130[b]	—
Mohs	3–4	3.4	—	—
Impact Str (Izod notched), ft-lb/in.	—	—	1.8, 0.7	—
Flex Str, 1000 psi	—	—	15–18, 10–15	12–15, 10–15
Compr Str, 1000 psi	>150	>150	35–42, 20–25	35–42, 20–25
ELECTRICAL PROPERTIES				
Vol Res, ohm-cm	$10^{13}–10^{17}$	$10^{13}–10^{17}$	$10^{14}–10^{15}, 10^{14}–10^{17}$	$10^{14}, 10^{14}$
Dielec Str (step by step, ¼ in.), v/mil	1000–2000	1000–2000	400–600, 400–500	270–400, 300–400
Dielec Const				
60 Cycles	5.4–8.7	6.5	7.5–7.6, 7.0–9.5	—
10^6 Cycles	5.4–8.7	6.5	7.4–7.9, 6.9–9.2	10–25, 10–40
Dissip Factor				
60 Cycles	0.0025	0.002–0.004	0.0035–0.0070, 0.007–0.050	0.0020–0.0040, 0.0025
10^6 Cycles	0.0001–0.0004	0.0001–0.0003	0.0015–0.0020, 0.0015–0.0120	0.0035
Arc Resistance, sec	High	High	300, 250	300, 250
FABRICATING PROPERTIES				
Machinability	Fair, readily punched	Fair, punches more readily than Natural	Fair to good; poor	Fair to good; poor
Moldability	—	—	Fair; good	Fair; good
HEAT RESISTANCE				
Max Rec Svc Temp, F	1110	1400–1800	600–1000, 500–800	600–700, 500–600
Heat Dist Temp (264 psi), F	—	—	850, 700	800, 650
Ther Shock Res	—	—	Moderate	Moderate
CHEMICAL RESISTANCE	Good res to most chemicals and molten materials exc hydrofluoric acid. Oils generally cause delamination	Slightly better chemical res than Natural; high res to oils. High res to high pressure, high temp water	Good res to organic solvents; poor res to strong acids and alkalis	Good res to organic solvents; fair res to strong acids and alkalis
USES	Furnace peepholes, boiler gage glass; capacitors, tube spacers	Experimental high temp tube spacers and waveguide windows; used to make glass-bonded synthetic mica	Electromechanical devices, high temp (660–900 F) insulators requiring high stability (e.g., computer parts)	Stable capacitors, tuners; high temp uses

[a] The first value or range in each column refers to glass-bonded mica produced by compression molding, the second to transfer molding.
[b] Rockwell.

Refractory Ceramics and Cermets

HIGH ALUMINA CERAMICS[a]

Type (% alumina) ➡	85%	95%	99+%
PHYSICAL PROPERTIES			
Specific Gravity	3.45	3.65	3.85
Ther Cond (200 F), Btu/hr/sq ft/°F/ft	6.2	10.3	10.7
Coef of Ther Exp, per °F			
77–390 F	3.1×10^{-6}	3.7×10^{-6}	—
77–750 F	3.7×10^{-6}	4.0×10^{-6}	—
77–1100 F	3.9×10^{-6}	4.3×10^{-6}	4.3×10^{-6}
77–1470 F	4.1×10^{-6}	4.5×10^{-6}	—
77–1830 F	4.3×10^{-6}	4.7×10^{-6}	—
Water Absorption, %	0.0	0.0	0.0
Max Rec Svc Temp, F	2460	3000	3540
ELECTRICAL PROPERTIES			
Dielec Str, v/mil	200	250	300
Dielec Const (77 F, 1 mc)	8.2	8.9	9.6
Power Factor (77 F, 1 mc)	0.0009	0.00035	0.00027
Loss Factor (77 F, 1 mc)	0.007	0.003	0.003
Te Value, F	1560	1960	2012
MECHANICAL PROPERTIES			
Mod of Elast in Tension, psi	32×10^6	40×10^6	50×10^6
Ten Str, 1000 psi	20	30	39
Flex Str, 1000 psi	41	45	47
Compr Str, 1000 psi	250	300	400
Hardness			
Mohs	9	9	9
Knoop	1450	1750	—
Impact Str (Charpy), in.-lb	6.5	7.0	—

[a] The values given are not maximum values and are dependent upon the minor components or fluxes used as well as a number of other factors.

ALUMINA CERMETS

Type ➡	Chromium-Alumina	Molybdenum-Chromium-Alumina[a]
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.21	0.22
Porosity, %	<0.25	<0.25
Melting Point (approx), F	3362	—
Ther Cond, Btu/hr/sq ft/°F/ft	29[a]	—
Coef of Ther Exp, per °F	4.7×10^{-6}[b]	5.2×10^{-6}[c]
Spec Ht (calc), Btu/lb/°F	0.16	0.14
Poisson's Ratio	0.22	0.25–0.27
MECHANICAL PROPERTIES		
Mod of Elast in Tension, 10^6 psi	41×10^6	$37–39 \times 10^6$
Ult Ten Str, 1000 psi		
Rm Temp	21	—
800 F	20.5	—
1200 F	20	—
1500 F	19.7	—
1800 F	16.8	—
2000 F	11.7	—
Hardness (Rockwell)	C37	C45–55
Mod of Rupture, 1000 psi		
Rm Temp	45	55[d]
1800 F	27	55
2100 F	18	29
2400 F	4.6	12
Compr Str, 1000 psi	110	240
Mod of Rigidity, psi	17×10^6	15×10^6
Shear Str, 1000 psi	40	—
Bulk Modulus, psi	21×10^6	26×10^6

[a] At 500 F. [b] At 32–1832 F. [c] At 68–1472 F.
[d] Addition of tungsten raises room temperature modulus of rupture to about 70,000 psi.

REFRACTORY OXIDES

Type ➡	Beryllia (BeO)	Calcia (CaO)	Magnesia (MgO)	Thoria (ThO_2)	Zirconia (stabilized ZrO_2)	Silica (vitreous SiO_2)
Melting Point, F	4620	4710	5070	6000	4710	—
Ther Cond (at spec temp and porosity), Btu/hr/sq ft/°F/ft	9.52 (2190 F, 5–10%)	4.12 (1830 F, 9%)	1.47 (2190 F, 22%)	0.0 (2190 F, 17%)	0.53 (2190 F, 28%)	0.80 (0.9%)
Coef of Ther Exp, per °F	52.8×10^{-7} (68–2550 F)	75.5×10^{-7} (68–2190 F)	77.8×10^{-7} (68–2550 F)	52.8×10^{-7} (68–2550 F)	30.6×10^{-7}[a] (68–2190 F)	2.8×10^{-7} (68–2280 F)
Max Use Temp in Oxidizing Atm, F	4350	4350	4350	4890	4530	—
Hardness (Mohs)	9	4.5	6	7	7–8	—
Thermal Shock Resistance	Excellent	Fair	Fair	Poor	Fair	Excellent
Stability in —						
Reducing Atmosphere	Excellent	Poor	Poor	Good	Good	Fair
Carbon	Excellent	Poor	Good	Fair	Fair	Good
Acid Slags	—	Poor	Poor	Poor	Good	Good
Basic Slags	Fair	Fair	Good	Good	Poor	—
Metals	Good	Fair	Fair	Excellent	Good	—

[a] Depends on degree of stabilization.

continued

Refractory Ceramics and Cermets—continued

CARBIDES

Type ➡	Silicon Carbide			Boron Carbide
	Silicate-Bonded	Silicon Nitride-Bonded	Densified	
PHYSICAL PROPERTIES				
Density, lb/cu in.	0.093	0.104	0.112	0.087[a]
Porosity, %	9–17	6–10	Negligible	Negligible
Ther Cond (2200 F), Btu/hr/sq ft/°F/ft	9	10	25[b]	16
Coef of Ther Exp (0–2550 F), per °F	2.4×10^{-6}	2.4×10^{-6}	2.17×10^{-6}	1.73×10^{-6}
Specific Heat (0–2550 F), Btu/lb/°F[a]	0.285	0.288	0.331	—
Max Service Temperature, F				
Inert Atmosphere	3200	3200	4000	4100
Oxidizing Atmosphere	2900	3000	3000	1000
MECHANICAL PROPERTIES				
Mod of Elast in Tension (77 F), psi	13.2×10^6	17×10^6	68×10^6	42×10^6
Tensile Strength (77 F), 1000 psi	Very low	3	25	22.5
Compressive Strength (77 F), 1000 psi	15	20	150	420
Modulus of Rupture (77 F), 1000 psi	2.2	5.5	24	50

[a] Boron carbide is available in densities ranging from 0.069 to 0.091 lb per cu in. [b] 1832 F.

CARBIDE-BASE CERMETS

Type (base) ➡	Titanium Carbide (TiC)[a]	Tungsten-Titanium Carbide ($WTiC_2$)[b]	Tungsten Carbide (WC)	Chromium Carbide (Cr_4C, Cr_7C_3, Cr_3C_2)[c]
Density, lb/cu in.	0.20–0.26	0.38–0.47	0.47–0.55	0.25–0.29
Ther Cond (68 F), Btu/hr/sq ft/°F/ft	—	16.5–32.9	25.7–50.1	—
Coef of Ther Exp (68–1200 F), per °F	$4.3–7.5 \times 10^{-6}$	$3.5–4.0 \times 10^{-6}$	$2.5–3.9 \times 10^{-6}$	$5.8–6.3 \times 10^{-6}$[f]
Electrical Conductivity, % IACS	1.34–6.0	4.3–5.8	5.0–10.1	2.58–2.78
Mod of Elast in Tension, psi				
70 F	$42–57 \times 10^6$	$65.5–80.6 \times 10^6$	$61.6–94.3 \times 10^6$	—
1600–1800 F	$33–48 \times 10^6$	—	—	—
Tensile Strength, 1000 psi[d]				
75 F	26–134 (0–61)	118–145	130[e]	36–37 (0)
1500 F	45–94 (0–2.7)	—	—	20–42 (0.2)
1800 F	35–72 (0–2.4)	—	—	—
Hardness (Rockwell)	A73–A91	A90–A93	A85–A93	A86.5–A89
Impact Strength (unnotched Charpy), ft-lb				
75 F	1.5–16	5.3–8.9	—	—
1800 F	2.5–16	—	—	—
Transverse Rupture Strength, 1000 psi	122–236	125–300	175–385	100–120
Stress-Rupture Strength (100 hr, 1800 F), 1000 psi	8–28	—	—	—
Compressive Strength, 1000 psi	265–450	585–705	518–800	422–480

[a] Property range covers grades ranging from 17.5% to 90% TiC with different binder metal contents.
[b] Property range covers various grades of different carbide-metal proportions.
[c] The type of chromium carbide and the type of binder metal affects properties.
[d] Elongation (%) in parenthesis. [e] Typical of one grade. [f] 68–576 F.

Refractory Ceramics and Cermets—concluded

OTHER CARBIDES

Type →	Beryllium Carbide (Be_2C)	Titanium Carbide (TiC)	Columbium Carbide (CbC)	Tantalum Carbide (TaC)	Zirconium Carbide (ZrC)
Ther Cond (68–795 F), Btu/hr/sq ft/°F/ft	12.1	9.9[a]	8.23[a]	12.8[a]	11.9[a]
Coef of Ther Exp (77–1472 F), per °F	5.8×10^{-6}	4.1×10^{-6}	—	4.6×10^{-6}	3.7×10^{-6}
Electrical Resistivity, ohm-cm[a]	1.1	1.05×10^{-4}	7.4×10^{-5}	2×10^{-5}	6.34×10^{-5}
Hardness (Mohs')	9+	8–9	9–10	9+	8–9
Compressive Strength, 1000 psi[a]	105	109	—	—	238
Mod of Rupture, 1000 psi[a]	16	—	—	—	—
Ther Shock Res (air quenched), cycles at designated temp range (F)	4 at 2000–1470	—	—	—	—
Fabrication Methods	Hot pressing, steel die pressing and sintering, hydrostatic pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering	Hot pressing, steel die pressing and sintering

[a] Room temperature.

MOLYBDENUM DISILICIDE (MoS_2)

Type →	Cold Pressed, Sintered	Hot Pressed
PHYSICAL PROPERTIES		
Density, lb/cu in.	0.216	0.224
Melting Point, F	3685 ±90	3685 ±90
Electrical Resistivity, microhm-cm		
77 F	—	21.5–27.2
2900 F	—	75–80
Coef of Ther Exp (78–2700 F), per °F	—	5.1×10^{-6}
MECHANICAL PROPERTIES		
Tensile Strength, 1000 psi		
1800 F	—	40
2000 F	—	42
2200 F	—	43
2400 F	—	41
Hardness		
Rockwell	C57[a]	A80–87[b]
Knoop (1 kg)	1065	850–870
Compressive Strength, 1000 psi	100[c]	350
Modulus of Rupture, 1000 psi		
77 F	51	36–57
1800 F	51–67	—
2000 F	51–86	72
2200 F	[d]	55
Stress-Rupture Strength (100 hr), 1000 psi		
1600 F	—	35
1800 F	—	29
1900 F	—	13.5
2000 F	—	8.5

[a] Superficial hardness.
[b] Some indentation cracking.
[c] Cast specimens.
[d] Test not applicable because bars showed too much plasticity.

NITRIDES

Type →	Boron Nitride	Silicon Nitride[a]
PHYSICAL PROPERTIES		
Density, lb/cu in.		
Theoretical	0.081	0.124
Actual	0.076	0.111
Melting Point, F	>3000[b]	3452[c]
Ther Cond, Btu/hr/sq ft/°F/ft	16.6, 15.4[d]	0.90[e]
Coef of Ther Exp (70–1800 F), per °F	4.3	1.37
MECHANICAL PROPERTIES		
Mod of Elast in Tension, 10^6 psi		
75 F	12.4×10^6	—
1300 F	1.5×10^6	—
Hardness		
Mohs	2	—
Rockwell	—	A99
Modulus of Rupture, 1000 psi		
75 F	15.9	10
1300 F	3.8	—
ELECTRICAL PROPERTIES		
Volume Resistivity, ohm-cm		
75 F	1.7×10^{13}	
900 F	2.3×10^{10}	
1800 F	3.1×10^4	Not applicable
Dielectric Constant (10^2–10^8 cps)	4.15	
Dissipation Factor		
10^2 Cycles	0.00103	
10^6 Cycles	0.00020	
10^{10} Cycles	0.0003	

[a] Mechanical properties are given for direction parallel to direction of forming pressure. Values perpendicular to this direction may be one-half to one-quarter of these values.
[b] May be used continuously at 3000 F, and higher under special conditions.
[c] Sublimes.
[d] Values at 570 F and 1800 F, respectively.
[e] 400–2400 F.

Glass (Industrial)

Type →	Fused Silica	96% Silica	Soda-Lime Glasses		Aluminum Silicate
			Plate	General Purpose	
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.079	0.078	0.09	0.089	0.091
Softening Point, F	3050	2800	1330	1285	1675
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	0.80	0.80	0.53	0.53	—
Coef of Ther Exp (32–570 F), per °F	0.30×10^{-6}	0.45×10^{-6}	4.8×10^{-6}	5.1×10^{-6}	2.3×10^{-6}
Spec Ht, Btu/lb/°F	0.185	0.185	0.20	0.20	—
Elec Res (212 F), ohm-cm	$>10^{15}$	$>10^{15}$	—	4×10^{9}	$>10^{15}$
Power Factor (68 F, 1 mc), %	0.025	0.02–0.04	0.80	0.90	0.37
Dielec Const (68 F, 1 mc)	3.75	3.8	7.4	7.2	6.3
Ther Stress Res, °F[a]	—	390	—	65	85
Ther Shock Res, °F[b]	Very high	Very high	135	125	240
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	10×10^{6}	9.7×10^{6}	$9–10 \times 10^{6}$	$9–10 \times 10^{6}$	12.7×10^{6}
Normal Work Stress (annealed), psi	1000	1000	1000	1000	1000
Max Rec Svc Temp, F					
Annealed	1650	1500	900	840	1200
Tempered	—	—	550	480	840
THERMAL TREATMENT					
Annealing Temp (stress relief), F	2080	1670	1010	950	1315
FABRICATING PROPERTIES					
Workability	Glass can be ground or polished without great difficulty. Machining limited to sawing or drilling. Sawing readily accomplished with an impregnated wheel. Drilling is difficult, but is done with special carbide-tipped drills using kerosene as a lubricant				
Joining	Glass can be joined by heat sealing using a blast lamp, a gas torch or electric heating. Parts must have closely similar coefficients of expansion; otherwise, intermediate pieces having intermediate coefficients must be used. Glass-to-metal seals are also made by this latter process				
CHEMICAL RESISTANCE	Glass is attacked by hydrofluoric acid, hot concentrated phosphoric acid and strong alkalis. It is resistant to most other chemicals				
USES	Ultraviolet energy transmission, chemical apparatus, thermocouple protection tubes, laboratory apparatus	Ultraviolet energy transmission, chemical reaction vessels, thermocouple protection tubes, laboratory apparatus	Sheet and plate glass, molded glassware, bulbs for electric lamps, bottles, vials, fluorescent lamp tubing		

[a] Measured by subjecting the two sides of a tube or constrained plate to a temperature differential. Index is the differential that causes a stress of 1000 psi on cooler surface.

[b] Measured by heating squares of annealed glass, 6 by 6 by ¼ in., to a uniform temperature and dropping into cold water. Index is maximum temperature differential at which no breakage occurs.

Glass (Industrial)—concluded

Type →	Borosilicate Glasses			Lead Silicate Glasses	
	Low Expansion Chemical Resistant	Baking and Kovar Sealing	Low Electrical Loss	Lamp Tubing	High Lead
PHYSICAL PROPERTIES					
Density, lb/cu in.	0.080	0.081–0.082	0.077	0.110	0.154
Softening Point, F	1500	1300–1425	—	1160	1075
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	0.67	—	0.67	0.50	0.45
Coef of Ther Exp (32–570 F), per °F	1.85×10^{-6}	$2.0–2.5 \times 10^{-6}$	1.8×10^{-6}	5.0×10^{-6}	5.1×10^{-6}
Spec Ht, Btu/lb/F	0.195	0.195	—	0.17	0.16
Elec Res (212 F), ohm-cm	10^{12}	3×10^{13}	$>10^{15}$	10^{14}	$>10^{15}$
Power Factor (68 F, 1 mc), %	0.46	0.26–0.28	0.06	0.16	0.09
Dielec Const (68 F, 1 mc)	4.6	4.7–5.1	4.0	6.6	9.5
Ther Stress Res, °F[a]	—	—	—	65	—
Ther Shock Res, °F[b]	320	—	—	120	—
MECHANICAL PROPERTIES					
Mod of Elast in Tension, psi	9.8×10^6	—	6.8×10^6	9.0×10^6	7.6×10^6
Normal Work Stress (annealed), psi	1000	1000	1000	1000	1000
Max Rec Svc Temp, F					
Annealed	900	800–840	810	720	720
Tempered	550	420–500	450	380	360
THERMAL TREATMENT					
Annealing Temp (stress relief), F	1020	890–975	910	800	800
FABRICATING PROPERTIES					
Workability	Glass can be ground or polished without great difficulty. Machining limited to sawing or drilling. Sawing readily accomplished with an impregnated wheel. Drilling is difficult, but is done with special carbide-tipped drills using kerosene as a lubricant				
Joining	Glass can be joined by heat sealing using a blast lamp, a gas torch or electric heating. Parts must have closely similar coefficients of expansion; otherwise, intermediate pieces having intermediate coefficients must be used. Glass-to-metal seals are also made by this latter process				
CHEMICAL RESISTANCE	Glass is attacked by hydrofluoric acid, hot concentrated phosphoric acid and strong alkalis. It is resistant to most other chemicals				
USES	Heat exchanger tubes, chemical apparatus, cooking ware, electrical insulators, sight and gage glasses, containers for chemicals and medicines, metal sealing, industrial piping, industrial glassware requiring thermal resistance, special lighting ware. heat resisting lenses			Lamp tubing, electrical and electronic applications, thermometer tubing, metal sealing	Electrical capacitors, x-ray shielding

[a] Measured by subjecting the two sides of tube or constrained plate to a temperature differential. Index is the differential that causes a stress of 1000 psi on cooler surface.

[b] Measured by heating squares of annealed glass, 6 by 6 by ¼ in., to a uniform temperature and dropping into cold water. Index is maximum temperature differential at which no breakage occurs.

Carbon and Graphite

Material →	Carbon	Graphite
PHYSICAL PROPERTIES		
Density, lb/cu ft	93.3–102.0	93.3–102.0
Ther Cond (212 F), Btu/hr/sq ft/°F/ft	3–5	70–86
Coef of Ther Exp (70–212 F), per °F	1.3–1.5 x 10^{-6}	1.0–1.3 x 10^{-6}
Specific Heat (100 F), Btu/lb/°F	0.18	0.18
MECHANICAL PROPERTIES		
Mod of Elast in Tension, psi	1.6–2.3 x 10^{6}	0.8–1.4 x 10^{6}
Tensile Strength, psi	900–1100	440–2000
Compressive Strength, psi	6300–9000	1700–7500
Flexural Strength, psi	2500–3000	800–4000
Hardness (scleroscope)	60–90	20–45
ELECTRICAL PROPERTIES		
Electrical Resistivity (68 F), microhm-cm	3500–4600	800–1300
Contact Resistance, ohms/sq in.		
Against Carbon	0.0058, 0.0026, 0.0017[a]	—
Against Copper	0.0133, 0.0093, 0.0042[a]	0.000704, 0.000315, 0.000162, 0.0000555[b]
Against Brass	0.038, 0.012, 0.0052[a]	0.00092, 0.000214, 0.000109[c]
Against Aluminum	0.138, 0.078, 0.015[a]	0.0448, 0.0067, 0.0020[c]
Against Graphite	—	0.000473, 0.000175, 0.000064, 0.000031[b]
Against Steel	—	0.01309, 0.00438, 0.00177, 0.000737[b]
FABRICATING PROPERTIES	Powdered material mixed with binder and shaped by molding under pressure or by extrusion, then baked above 1800 F	
CHEMICAL RESISTANCE	Carbon begins to oxidize in air at approximately 630 F and graphite at approximately 810 F, although the rate of oxidation is not rapid even at high temperatures. With a steam or a carbon dioxide atmosphere, temperature can be raised above a red heat before excessive oxidation occurs. Alkalis in solution do not attack these materials but fused hydroxides and carbonates attack them at high temperatures. They are not attacked by dilute acids, including hydrofluoric, but strongly oxidizing chemicals will attack them	
USES	Mechanical: sealing rings, pump and valve parts, bearings, pistons, and piston rings. Electrical: battery carbons, contacts, welding carbons, anodes, brushes for electrical machines. Refractory: linings, molds, continuous casting dies, furnace boats. Chemical: pipe, pumps, fittings, heat exchangers, valves, towers and accessories, porous filtering media	

[a]Pressures of 5, 25 and 75 psi, respectively.
[b]Pressures of 25, 150, 400 and 1000 psi, respectively.
[c]Pressures of 25, 150 and 400 psi, respectively.

Mineral Fibers

Type →	Glass			Asbestos			Ceramic (aluminum silicate)
	Standard	Micro		Chrysotile	Crocidolite	Amosite	
		Quartz	Glass				
COMPOSITION AND FORM							
Chemical Base	—	Silica glass	—	Hydrous magnesia silicates	Hydrous sodium and iron silicates	Iron and magnesium silicates	—
Color	Blue-white	Tan	—	Green, grey, white	Yellow-brown	Yellow-brown	Opaque white
Fiber Length, in.	Filament or staple	Staple	Staple	Crude ⅜–¾	Crude ⅜–¾	2–11 in.	Very short
Fiber Width (avg), microns	5–16	0.75	0.05–1.5	0.1	—	—	3
PHYSICAL PROPERTIES							
Specific Gravity	2.54	—	2.54	2.4–2.6	3.2–3.3	3.1–3.25	—
Ten Str, psi	205–212	—	—	80–100	100–300	16–90	—
Elong, %	2–3.7	—	—	Low	Low	Low	—
Moisture Abs, %	Poor	Poor	Poor	Fair	Fair	Fair	Poor
Spec Ht, Btu/lb/°F	0.1	0.1	0.1	Contains 14% water	—	—	—
Specific Heat, Btu/lb/°F	0.157	—	0.157	0.266	0.201	0.193	—
Ther Cond (1000 F), 10^{-4} Btu/hr/sq ft/°F/ft	—	330–1000[a]	—	980[b]	—	—	190–1170[c]
Vol Res, ohm-cm	2×10^{11}	10^{15}	2×10^{11}	—	—	—	High
ENVIRONMENTAL PROPERTIES							
Acid Resistance	Resists all but hydrofluoric and hot phosphoric	Resists all but hydrofluoric and hot phosphoric	Resists all but hydrofluoric and hot phosphoric	Soluble to 57%	Good	Fair	—
Alkali Resistance	Dissolves in strong	Dissolves in strong	Dissolves in strong	Good	Good	Fair	—
Heat Resistance[d]							
Below 600 F	Exc	—	—	Fair, embrittles	Loses water at mod temp	Fair, embrittles	Little effect, keeps resilience
600 F	Softens	OK	Softens	8.4% loss in ten str	Embrittles, loses character	Embrittles, loses character	OK
800 F	NG	OK	—	26.7% loss in ten str	NG	NG	OK
1000 F	NG	Shrinks slightly	Max (as felt)	40.5% loss in ten str	NG	NG	OK
1200 F	NG	Shrinks slightly	NG	68% loss in ten str	NG	NG	OK
2000 F	NG	Shrinks slightly	NG	Embrittles, loses character	NG	NG	OK—still resilient
Fusing Temp, F	1500	2500	1500	2770	2180	2550	2800

[a] Felted; density 3 lb per cu ft.
[b] 75 F.
[c] Felted.
[d] NG = No good.

Synthetic Fibers

Type →	Regenerated Cellulose (rayon)				Cellulose Acetate (acetate)	66 Nylon			Fluorocarbon (Teflon)	Polyester (Dacron)
	Viscose									
	High Tenacity[a]	Regular	Cupram-monium	Fortisan 36						
COMPOSITION AND FORM										
Chemical Base	Regenerated cellulose		Regenerated cellulose	Saponified cell. acetate	Cellulose acetate	Polyamide			Polytetra-fluoroethylene	Polyethylene terephthalate
Color	White	—	White	White	White	White			Brown	White
Fiber Width (avg), microns	10–15	10–43	11	—	11–46	10+			—	—
Cross Section	Irregular	—	Circular	Irregular	Irregular	Circular			Circular	Circular
PHYSICAL PROPERTIES										
Specific Gravity	1.5	1.5	1.54	1.52	1.3	1.14			2.3	1.38
						Reg	High	Staple		
Ten Str										
70 F, 65% RH, 1000 psi	85–95	29–47	33–42	138–155	20–25	67–85	89–108	60–66	44	85–106
Wet, % of normal	55–65	44–54	59	65–70	60–65	100	100	100	100	98
Elong, %	10–20	15–30	10–17	6.2	23–30	26–32	19–24	37–40	24	12–40
Stiffness, gm/grex	25	11	14	—	5.2	20	41–47	—	—	13–25
Strain Rec (2% strain unless noted), %	82	82	48 at 5%	—	94	100[b]	100[b]	100[b]	—	90–100
						75 at 20%				
Toughness Index (relative work to rupture)	25	19	14	—	19	56	52	—	Good	49–63
Friction Coef (Self)	0.19	—	—	—	0.29	0.14–0.16			Low	—
Flammability	Highly flammable		Highly flammable	Burns	Burns	Not support combustion			Fire resistant	Slow burn
ENVIRONMENTAL PROPERTIES										
Acid Resistance										
Strong	Decomposes		Decomposes	Poor	Decom-poses	Poor			Inert	Good at low temp
Weak	Strength loss		Decom-poses	Poor	Dissolved by some	Fair			Inert	Res
Alkali Resistance										
Strong	Swells		Swells	Swells	Saponifies	Good			Inert	Fair at low temp
Weak	Res (cold)		Res (cold)	Res (cold)	Res (cold)	Good			Inert	Good at low temp
Organic Solvents	Res		Res	Res	Dissolved by many	Generally insoluble			Inert	Res
Sunlight Effect	Weakens		Res	Res	Weakens	Weakens			Inert	Weakens
Microbiological Res	Attacked		Attacked	Attacked	Res	Res			Inert	Res

[a]Super Cordura.
[b]Delayed recovery up to two weeks.

Synthetic Fibers—concluded

Type ➡	Acrylic			Vinyl Derivative			Protein (Vicara)
	Orlon	Acrilan	Dynel	Vinyon	Saran	Polyethylene	
COMPOSITION AND FORM							
Chemical Base	Polyacrylo-nitrile	Acrylic copolymer	Vinyl chloride-acrylonitrile copolymer	Vinyl chloride-vinyl acetate	Vinylidene chloride	Polyethylene	Zein (corn protein)
Color	Cream	White	Light cream	White	White	White	Beige-white
Fiber Width (avg), microns	—	—	—	16–18	50–1300	150+	15–30
Cross Section	Flattened tube	Flattened tube	Flattened tube, convoluted	Bar bell	Circular	Circular	Circular
PHYSICAL PROPERTIES							
Spec Grav	1.14–1.17	1.2	1.30	1.33	1.68–1.75	0.92	1.25
Ten Str							
70 F, 65% RH, 1000 psi	77	44–66	42–45	35–76	15–45	11–32	17.5–19
Wet, % of normal	95	80	100	100	100	100	45–55
Elongation, %	16	31	33–38	14–35	20–30 at break (oriented)	20–80	30–35
Stiffness, gm/grex	28–30	8	6.3	22	20	2–12	2.8–3.4
Strain Rec (2% strain unless noted), %	85	80	97	99	95	90–95 slow	99 at 4%
Toughness Index (relative work to rupture)	44	32–40	48	30–36	—	30	18–21
Friction Coef (self)	—	—	—	0.19	—	—	—
Flammability	Slow burn	Slow burn	Self-extinguishing	Not support combustion	Not support combustion	Slow burn	Burns
ENVIRONMENTAL PROPERTIES							
Acid Resistance							
Strong	Inert	Inert	Res	Res	Res	Res	Res to 10% conc
Weak	Inert	Inert	Res	Res	Res	Res	Decomposes
Alkali Resistance							
Strong	Attacked	Attacked	Very res	Res	Res most	Res	Decomposes
Weak	Fair-good	Fair	Very res	Res	Res	Res	Res (cold)
Organic Solvents	Generally res	Very res	Generally good	Poor	Generally res; swells	Generally good	Res
Sunlight Effect	Very res	Res	Slight str loss	Res	Tends to yellow	Weakens	Res
Microbiological Resistance	Res	Res	Res	Res	Res	Res	Res

Natural Fibers

Type →	Cotton	Bast				Hard			Animal		
		Flax	Jute	Hemp	Ramie	Manila (abaca)	Sisal	Henne-quin	Wool	Horse-hair	Silk
FORM											
Fiber Length, in.	½–2½	6–40	10–60	40–80	15–25	20–40	24	20	1½–15	1–25	Filament
Fiber Width (avg), microns	17	16	17	20	47	19	19	20	28	100	11
Cross Section	Flat tube	Tube	Bunched cells	—	Flat tube	Bunched cells	Bunched cells	Bunched cells	Round	Round	Round
PHYSICAL PROPERTIES											
Specific Gravity	1.55	1.50	1.48	1.48	1.55	—	—	—	1.30	1.30	1.60
Ten Str											
70 F, 65% RH, 1000 psi	42–125	115	—	112–132	130	125	100–120	—	17–28	—	45–83
Wet, % of normal	120	—	Low	Low	High	High	Low	Low	79–97	—	75–95
Elong, %	3–10	3	—	2–6	3–6	2–3	2–2.5	—	25–50	—	13–31
Stiffness, gm/grex	57–60	270	185	200	167	175	127	—	3.9	—	0.75–1.16
Strain Rec (2% strain unless noted), %	74, 45 at 5%	65	74 at 1%	—	52	—	—	—	99+, 63 at 20%	99, 63 at 20%	74
Toughness Index (relative work to rupture)	14	6	2	4	8	7	5	—	20	—	44
Strength Ratio (yarn to fiber)	0.45–0.60	0.38	0.35	0.36	0.45	—	—	—	0.50–0.55	—	—
Friction Coef (self)	0.30	—	—	—	—	—	—	—	0.20–0.50	—	0.26
Flammability	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Burns	Slow burn	Slow burn	Burns
ENVIRONMENTAL PROPERTIES											
Acid Resistance											
Strong	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Poor	Res	—	Dissolves
Weak	Poor	Poor	—	Poor	—	—	—	—	Res	—	Fair
Alkali Resistance											
Strong	Exc	Good	Good	Good	Good	Good	Good	Good	Poor	Poor	Dissolves
Weak	Exc	Good	Good	Good	Good	Good	Good	Good	Poor (hot)	Poor	Poor
Organic Solvents	Res	Res	Res	Res	Res	Res	Res	Res	Res	Res	Res
Heat Effect	Good to 275 F	Good to 275 F	—	Good to 275 F	Good to 275 F	—	—	—	Good to 212 F	—	Disinte-grates at 340 F
Sunlight Effect	Weakens	None	None	None	None	None	None	None	Weakens	Weakens	Weakens
Microbiological Resistance	Poor	Very good	Good	Good	Exc	Good	Poor	Poor	Fair	Fair	Good

Woods and Composition Board

AMERICAN WOODS[a]

Hardwood Type[b] ↓	Specific Gravity	Bending Stress, psi[c]	Max Crushing Str (compr), psi[d]	Softwood Type[e] ↓	Specific Gravity	Bending Stress, psi[c]	Max Crushing Str (compr) psi[d]
Ash (white)	0.60	8,900	7,410; 1,410	**Cedar** (Port Orford)	0.42	7,700	6,470; 760
Basswood	0.37	5,900	4,730; 450	**Cedar** (eastern red)	0.47	3,800	6,020; 1,140
Beech	0.64	8,700	7,300; 1,250	**Cypress** (southern bald)	0.46	7,200	6,360; 900
Birch (yellow)	0.62	10,100	8,170; 1,190	**Douglas Fir** (coast type)	0.48	8,100	7,420; 910
Cottonwood (black)	0.35	5,300	4,420; 370	**Fir** (balsam)	0.36	5,200	4,530; 380
Elm (rock)	0.63	8,000	7,050; 1,520	**Hemlock** (eastern)	0.40	6,100	5,410; 800
Gum (sweet red)	0.49	8,100	5,800; 860	**Hemlock** (western)	0.42	6,800	6,210; 680
Gum (tupelo)	0.50	7,200	5,920; 1,070	**Pine** (eastern white, northern white)	0.36	6,000	4,840; 550
Hickory (shagbark)	0.69	8,900	8,000; 2,220	**Pine** (longleaf)	0.58	9,300	8,440; 1,190
Locust (black)	0.69	12,800	10,180; 2,260	**Pine** (ponderosa)	0.40	6,300	5,270; 740
Maple (sugar)	0.63	9,500	7,830; 1,810	**Redwood** (virgin)	0.40	6,900	6,150; 860
Oak (red)	0.63	8,400	6,920; 1,260	**Spruce** (Sitka)	0.40	6,700	5,610; 710
Oak (white)	0.68	8,200	7,440; 1,320				
Poplar (yellow)	0.40	6,100	5,290; 580				
Walnut (black)	0.55	10,500	7,580; 1,250				
Willow (black)	0.37	3,900	3,420; 480				

[a] Test pieces air dried to 12% moisture content.
[b] "Hardwood" refers to deciduous trees (lose leaves seasonally); the term has no relation to the hardness of the wood.
[c] Static bending stress at the proportional limit.
[d] First value is longitudinal, second is transverse.
[e] "Softwood" refers to coniferous trees (retain leaves); the term has no relation to the softness of the wood.

WOOD COMPOSITION BOARD

Class →	Hardboard (fibrous)[a]			Particle Board[b]		Softboard (insulation)[c]		
	Untreated	Treated	Special Densified	Low Density[d]	High Density	Semirigid	Rigid	Intermediate Density
PHYSICAL PROPERTIES								
Specific Gravity	0.88–1.04	0.95–1.15	1.35–1.45	0.40–0.80	0.80–1.05	0.02–0.15	0.15–0.40	0.40–0.80
Density, lb/cu ft	50–65	60–70	85–89	25–50	50–70	1.5–9	9–25	25–50
Ther Cond, Btu/hr/sq ft/°F/in.	0.80–1.40	1.50	1.85	0.40–0.80	—	0.24–0.27	0.27–0.40	0.40–0.80
Water Abs (24 hr), %	3–18	3–13	0.3–1.2	5–50	15–40	—	—	—
Max Linear Exp, %[e]	0.60	0.40	—	0.40	0.85	—	0.50	1.30
MECHANICAL PROPERTIES								
Ten Str, psi								
Par. to Surface	1000–3000	4000–5500	7700	100–1350	300–2500	—	200–500	800–2000
Perp to Surface	—	—	500	90–400	275–400	—	10–25	—
Mod of Elast in Bend, 1000 psi	400–800	800–1000	1250	300–700	400–1000	—	25–125	90–700
Compr Str (par.), psi	1800–6000	4200–5300	26,500	—	3500–4000	—	—	500–3400
Mod of Rupture, 1000 psi	3–7	7.5–10	10–12	0.4–4.0	3.0–7.5	—	0.2–0.8	0.4–4.0

[a] Made by felting ligno-cellulosic wood fibers formed by steam exploding or mechanical fiberizing.
[b] Made of flakes, chips, splinters or particles of wood bonded with synthetic resin or other binder.
[c] Made from wood pulp or bagasse (processed sugar cane), bonded by felting properties of fiber.
[d] Does not include extruded board.
[e] Expansion resulting from change in moisture content from equilibrium at 50% RH to equilibrium at 97% RH.

Mechanical Felts

SHEET AND ROLL FELTS

Type[a] ↓	Nominal Density, lb/cu ft	Typical Applications	Classification[b]
SHEET FELT			
Rock Hard	43	Heavy duty grinding and polishing wheels, bumpers	32-S-1, 32-S-2, 32-S-3, 32-S-4
Hard	35	Polishing granite, marble, glass tumblers; marking pens	26-S-1, 26-S-2, 26-S-3, 26-S-4
Medium	27	Polishing lenses, mirror and plate glass, and wood; cash carrier heads, bumpers, ink rollers, punched wicks	20-S-1, 20-S-2, 20-S-3, 20-S-4
Soft	21	Wicks, washers, plugs, transfer rolls, polishing blocks	16-S-1, 16-S-2, 16-S-3, 16-S-4
Extra Soft	16	Fine and soft metal polishing, absorbent pads, shock mountings, antivibration pads	12-S-1, 12-S-2, 12-S-3, 12-S-4
ROLL FELT			
Back Check (F-1, F-2, F-3)	21	Washers, bushings, wicks, ink rolls and pads, door bumpers, polishing blocks, wheels and pads, antivibration and dampening pads, window channels, oil and grease shields	16-R-1, 16-R-2, 16-R-3
Extra Firm Pads (F-5, F-6, F-7)	16	Dust shields, wipers, grease-retaining washers, wicks, antivibration mountings	12-R-1, 12-R-2, 12-R-3
Firm Pads (F-10, F-11, F-12, F-13, F-15)	11.3	Grease and oil retainers, dust shields, sound deadening, chassis strips, pedal pads, dash liners	9-R-1, 9-R-2, 9-R-3, 9-R-4, 9-R-5
Soft Pads (F-26)	9.6	Packing and padding	8-R-16
Ball Bearing (F-50, F-51)	21	Ball and roller bearing oil retainers; small dust-excluding washers; gaskets, liners, other thin cut parts	16-RX-1, 16-RX-3
Lining (F-55)	16	Antisqueak strips; lining cemented to fiber board and metal panels	12-RX-3

[a]SAE Spec No. in parenthesis.
[b]Felt classifications are based on the construction, i.e., fiber blends or "mixes," and density of the material. Several types, serving assorted uses, are customarily fabricated in each of the principal classes.
Standard nomenclature consists of a three-unit code in which the first number indicates the surface density (weight equivalent of 1 sq yd 1 in. thick); a letter ("S" for felts fabricated in sheets 36 x 36 in., "R" for felts fabricated in rolls 40 yd long and 60 or 72 in. wide); and a second number indicating the type of fiber composition, which has a basis in the U. S. Standard wool grade classification.

FILTER FELTS

Type[a] ↓	Nom Thk, in.	Density, lb/cu ft	Mullen Bursting Strength, psi[b]	Porosity, %	Air Permeability, cfm/sq ft/ 0.5 in. H_2O	Retention Efficiency, %[c]	Use
A (all wool)	1/32	10	50	93	280	45	Multilayer latex filter
B (all wool)	1/16	9	94	86	235	65	Air conditioning and pollen filtering
C (all wool)	1/16	11	125	86	130	76	Emulsion and dope
D (all wool)	1/16	13	130	86	105	88	Industrial air conditioning
E (all wool)	3/64	14	110	83	70	92	Air compressors; compressed air
F (cotton blend)	1/32	11	225	86	50	94	Cellulose lacquer and organic solvents
G (all wool)	1/32	17	220	66	30	96	Oil and fuel
H (all wool)	1/16	20	145	79	28	98	Industrial respirators and masks
I (all wool)	1/16	22	120	79	13	99	Biochemical air intake filters
J (silk blend)	1/16	30	235	62	2	100	Toxic dusts, fumes and mists

[a]Filter felts are made of special wool fiber blends chosen for their ability to make a felt of specific porosity, permeability and retention characteristics.
[b]ASTM D461-53.
[c]Retention of 0.7 micron mean dia mineral dust at rated permeability.

ROLL FELTS[a]

SAE Spec No. ↓	Nom Thk, in.	Density, lb/cu ft	Breaking Strength, psi		Splitting Resistance (2-in. width), lb		Wool Content, %	Solubles, %			Ash, %
			L[b]	W[b]	L[b]	W[b]		Carbon Tetra-chloride	Water	Com-bined	
F-1	¼	22.1	810	835	38	36	98	0.9	0.9	1.9	0.5
	½	19.3	850	720	42	44	98	0.8	1.5	2.3	0.6
F-3	¼	20.0	450	490	26	24	94	2.1	1.7	3.8	1.2
	½	20.1	475	550	32	29	95	2.1	1.2	3.3	1.0
F-5	¼	15.0	640	450	18	18	98	1.1	1.4	2.4	0.7
	½	15.4	640	565	21	19	97	0.6	1.6	2.2	0.6
F-10	¼	11.4	380	280	9	8	98	0.6	1.1	1.8	0.6
	½	11.0	400	325	8	8	98	0.5	1.3	1.8	1.0
F-11	¼	11.8	310	230	8	9	94	3.1	1.6	4.7	1.0
	½	12.2	300	240	9	9	94	3.7	1.2	4.9	0.9
F-15	¼	10.7	170	130	6	5	86	1.6	2.8	4.4	1.8
	½	11.2	180	130	4	4	88	1.7	2.8	4.5	1.9

[a]Typical test data obtained by ASTM D461 methods; not specifications.
[b]L=lengthwise; W=transverse.

SAE Spec No. ↓	Abrasion Wear, % decr in thk[a]			Coef of Static Friction[b]				Oil Absorption and Capillary Flow (SAE 20 oil, 70 F)								Ther Cond (K), Btu/hr/sq ft/ °F/ft[c]
	Load, oz/sq in.							Oil Absorption (24 hr), % wt incr	Oil Wicking Rate, in./min lapsed time							
	3.8	7.0	10.2	Wood	Glass	Metal	Oiled Metal		5	10	15	30	60	90	120	
F-1	1.0	2.3	2.1	.37	.26	.22	.18	185	0.5	0.7	0.8	1.1	1.6	2.0	2.2	0.030
F-3	2.1	2.1	3.0	.37	.26	.22	.18	265	0.5	0.7	1.0	1.3	1.7	1.8	2.1	0.030
F-5	3.0	3.0	6.0	.37	.26	.22	.18	320	0.6	0.8	1.0	1.3	1.7	1.9	2.0	0.025
F-15	4.1	7.6	18.5	—	—	—	—	570	0.6	0.9	1.1	1.4	1.6	1.8	1.9	0.020

[a]Felt-to-felt, 10,000 rubs, 8-in. stroke. [b]Felt against material indicated.
[c]1-in. felt. Thermal and acoustical felts blended with Kapok fiber nave tested values of 0.21 K factor and 0.80 sound absorption coefficient at 512 cps for 1-in. thicknesses of 3.2 lb per sq yd weight.

SAE Spec No.[a] →	F-1 (21)		F-3 (21)		F-5 (16)		F-10 (11.3)		F-11 (11.3)		F-15 (11.3)	
	Load, psi	Compr Set, %	Load, psi	Compr Set, %	Load, psi	Compr Set, %	Load, psi	Compr Set, %	Load, psi	Compr Set, %	Load, psi	Compr Set, %
Deformation, %												
10	21	1	13	1	6	1	4	1	4	1	3	1
30	110	4	93	6	41	4	9	3	15	4	10	4
50	480	11	420	12	215	10	58	9	72	9	64	10
80	27,900	53	21,200	55	7750	53	2380	40	2620	42	3420	42

[a]Density (lb per cu ft) given in parenthesis.

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BORON NITRIDE An easily machined, impermeable ceramic material with unique electrical and corrosion resistance properties for use up to 3000 F.	Density, gms/cc — 2.10 min. (true density, gms/cc — 2.25); working temperature: inert atmosphere, solid — 3000°F. max.; powder — 5000°F. max.; oxidizing atmosphere, solid — 1800°F. max.; powder — 1300°F. max.; dielectric constant — 4+; dielectric strength — high; electrical resistivity — high; coefficient of friction — low; thermal shock resistance — excellent; permeability — negligible; flexural strength — good; hardness, Moh's scale — 2.	Can be machined at high speeds without lubricant with standard steel cutting tools. May be threaded or otherwise physically joined to form strong, sizeable assemblies.	Solid and powder form. Has hexagonal crystalline structure similar to graphite.	Vacuum tube separators; dielectric applications; electrical insulators; chemical equipment parts; molten metal pump parts; combustion chamber liners; melting crucibles; thermocouple protection tubes; mold release agents; gaskets; seals; rupture discs.
KT SILICON CARBIDE Extremely hard, self-bonded impermeable ceramic for use up to 4000 F.	Very hard; negligible permeability; exceptional abrasion and corrosion resistance; working temperature to 4200 F in inert atmosphere, to 3000 F in oxidizing atmosphere; high modulus of elasticity, flexural strength, compressive strength, thermal conductivity; low thermal expansion; excellent resistance to thermal shock.	Standard ceramic forming techniques can produce large intricate shapes to .007" tolerance on unground surfaces and to .001" on ground surfaces. Diamond grinding necessary for finish machining, can produce very high surface finish (5 micro-inches).	Solid form.	Wear-resistant parts; crucibles; heat exchanger parts; valves for corrosives; pipe and fittings; nuclear reactor structural parts; rocket nozzles; nose cones; leading edges.
FIBERFRAX® A fibrous insulation medium above the practicable temp range of mineral wool, glass & asbestos.	Melting point over 3000 F; maximum use temp 2300 F; low thermal conductivity; castable forms exhibit exceptional thermal shock resistance.	Extremely diverse fabricating possibilities due to wide variety of forms available.	Bulk; long & short staple fiber; batts; board; paper; blocks; castable compositions; molded shapes; roving; yarn; wicking; rope; tape; cloth; braid.	Thermal, acoustical and electrical insulation; high temperature gas filters; gaskets; packings; liners for aluminum pouring troughs; vacuum outgassing of reactive metals; protective cushion in honeycomb brazing; protective coatings for metals and graphite.
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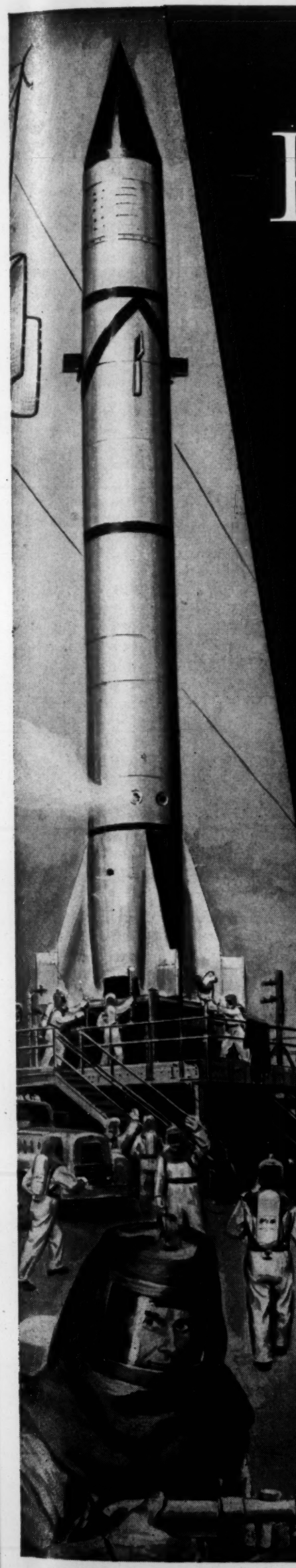
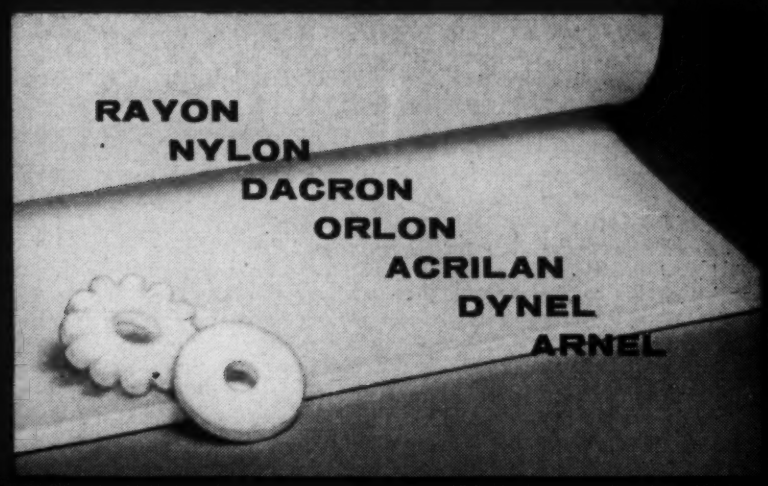


SYNTHETIC-FIBER

FEUTRON FELTS



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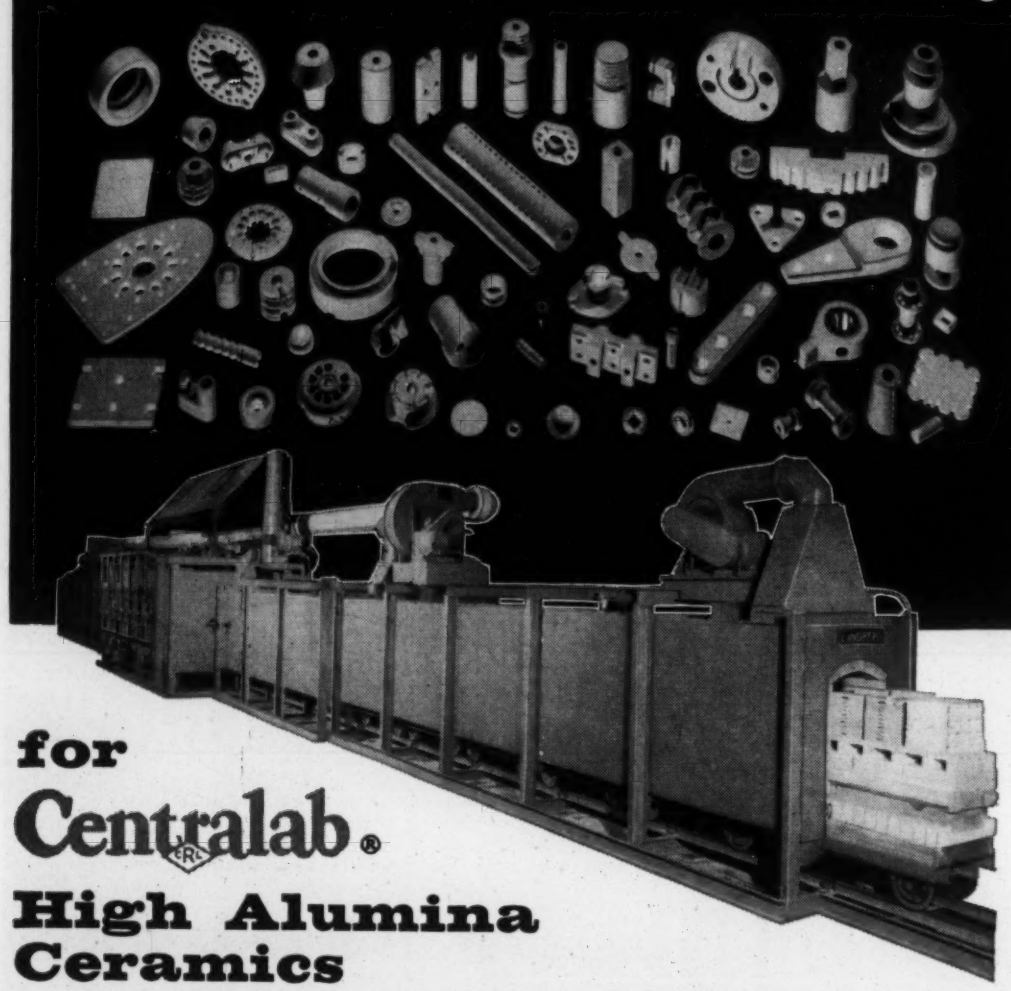

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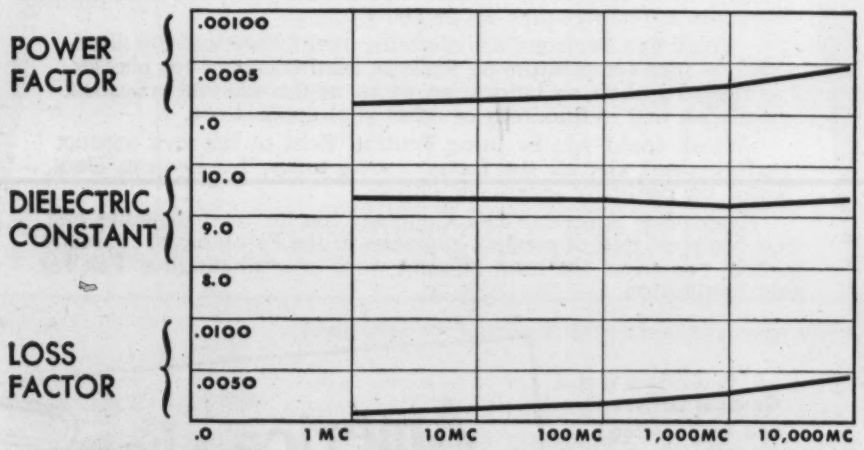

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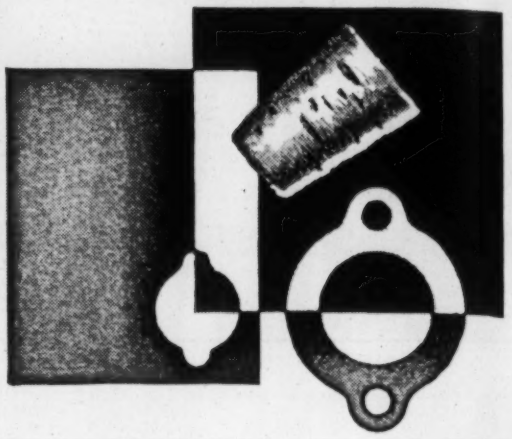

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Paper-base components may well cost you *a tiny fraction* of components made of metal, cloth, glass, or plastics. And they may also give you vastly improved performance. Let Knowlton's research, technical and pilot-plant facilities solve your problem simply, efficiently, and economically.

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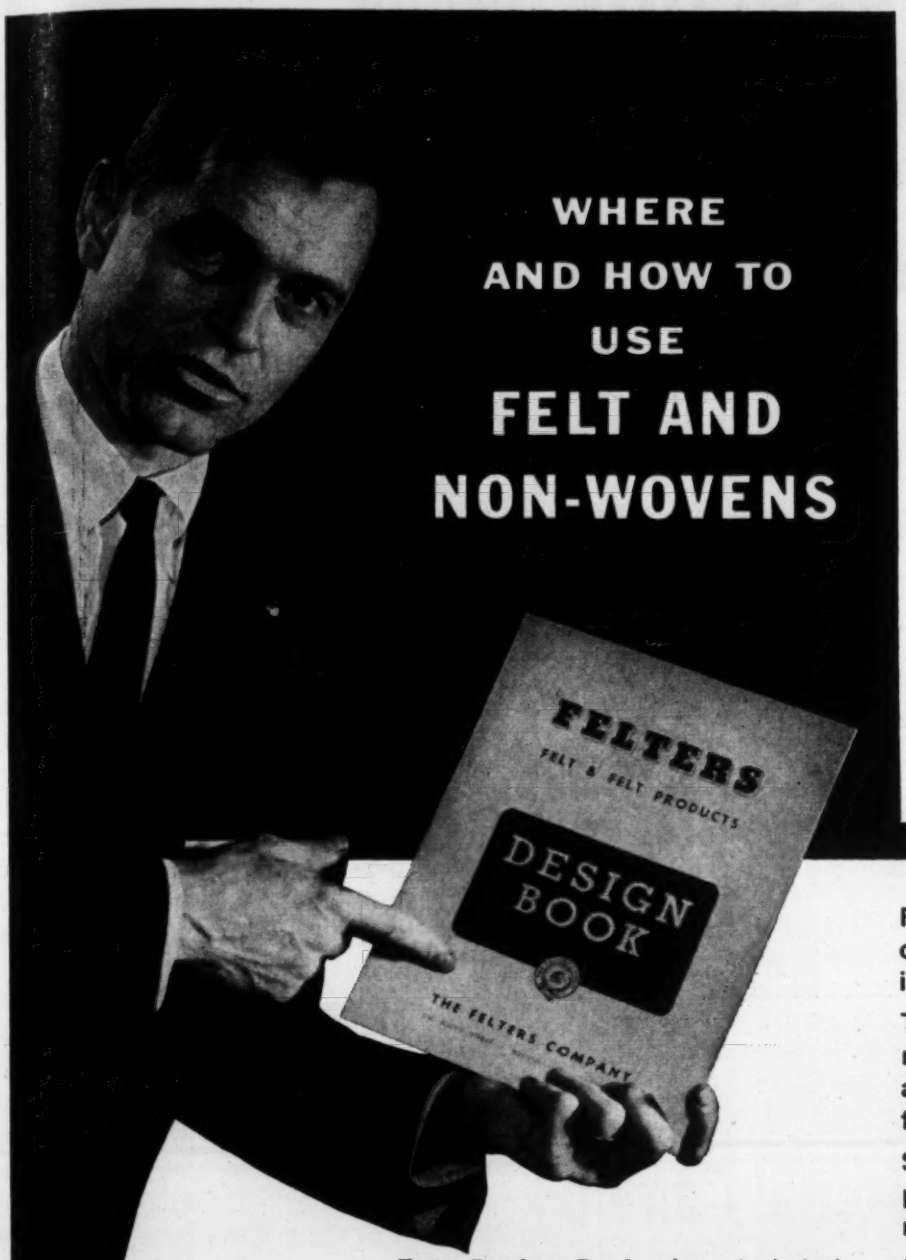


WHERE AND HOW TO USE FELT AND NON-WOVENS

Free Design Book gives technical data on design properties, special treatments and selection. Send for your copy.

Felters' Cut Part serves as combination gasket, dust and light shield for nameplate on Plymouth Pushbutton Shift Panel.

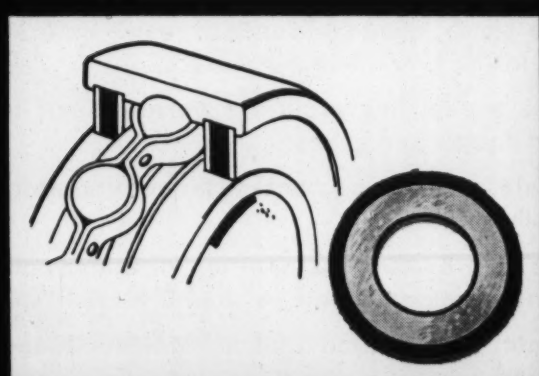
Felters' range of non-woven and felted-type fabrics offer wide combinations of characteristics not found in any other material.

These fabrics can be made tough, stiff or dense, as required. Also water repellent, flameproof, and moth and mildewproof. Ideal for absorptive wicking and filtering applications.

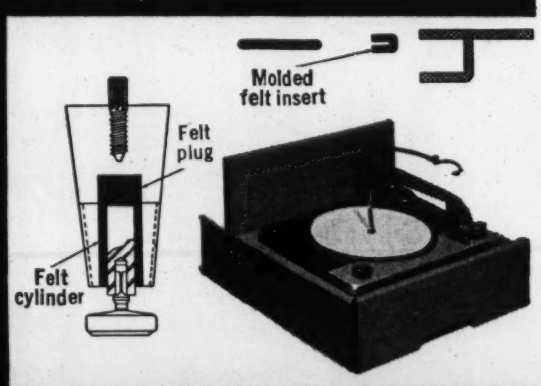
Synthetics, too, are giving non-wovens new uses and properties, particularly in smoothness, abrasion resistance, and long life.

Call on Felters for all types of felt and non-woven fabrics, including special treatments, impregnations and fiber mixes.

AllFab is a special Felters' non-woven fabric. Has thermoplastic resin binder and can be electronically stitched, sealed and embossed. Available in wide range of fiber combinations in thicknesses from 1/16" to 1" and more. Used for backing, filling, and plumping. Available with synthetic mixes such as Orlon®, with varying degrees of "loft."



Felt Pads (Prelubricated) prolong bearing life! Special tests show that oil saturated felt rings provide a built-in "slow bleeding" action to lubricate bearings. Functions over wide temperature range at speeds up to 10,000 rpm, without excessive starting friction at low temperature or poor stability at high temperature.



Hi-Fi Sets Use Felt in a number of places. Record changer drawers slide on aluminum channel with molded in felt insert. This provides light compression fit, eliminates resonant metal-to-metal contact, absorbs vibration and insures smooth action. Special felt lined piston legs eliminate floor vibration which affects performance.

the **FELTERS** company

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Pioneer producers of Felt and Felt Products

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- ★ Resist surface atmospheric action while retaining constant and reproducible contact resistance.
- ★ Be readily processed to provide low friction (graphite) or high friction (carbon) or any desired intermediate value.
- ★ Withstand electric arcing in contacts, lightning arresters and similar applications without appreciable dimensional changes.
- ★ Serve as an electrical conductor which is readily machinable and can operate satisfactorily up to 6,000°F.

No Other Material Can Do ALL of These:

- ★ Resist corrosive action of most gases and chemicals.
- ★ Serve as a semi-permanent, readily-formed mold for casting metals or glass.
- ★ Act as a seal ring around a moving shaft to retain liquids and gases.
- ★ Operate as a sliding contact on commutators and slip rings.
- ★ Serve as a bearing material for vacuum applications or as an insert in ordinary bearings.
- ★ Operate as a friction unit in constant-speed clutches.
- ★ Serve as a non-welding contact, either by itself or in combination with other metals.

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"Industrial Textile Fibers," 16 pp. Textile fibers are engineering materials. But not until recent years—since the rapid development of synthetics—have they been treated as such. This manual takes the engineering approach to the selection of, and designing with, fibers. It covers the characteristics, properties and uses of: Natural fibers; Mineral and Inorganic fibers; and Man-made fibers.

"How to Select and Specify Glass," 16 pp. To select a glass intelligently you must know how the properties of glass differ from those of other engineering materials, and what combination of properties each type of glass has. To design and specify glass parts economically, you must know in what form each combination of properties is commercially available. This manual aids the designer or engineer in selecting glass by providing: Physical and Mechanical Properties; Forms Commercially Available; General Design Recommendations; and Characteristics of Specialty Glasses.

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how much Dust can a filter collect?

UP TO 99.99%

if it uses WESTERN FELT!

Such efficiency is possible in a Hersey reverse-jet filter with particle size of 5 microns and a pressure drop of ½ inch of water.

Felt can be used to filter solids from solids, solids from liquids, or solids from gases. It is used effectively in fuel filters, air filters, chemical filters, respirators, or dust collectors.

Microscopic barbs on the live fibers of Felt make felt the ideal filtering medium. These scales collect and hold dust particles. They also encourage "build-up" or caking which actually increases filter efficiency. At the same time, their natural interlocking action holds fibers tightly together, through years of flexing.

For helpful engineering information on filtration felts, write

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Just Published!

Effects of RADIATION on Materials

Edited by **J. J. HARWOOD,** U. S. Office of Naval Research; **HENRY H. HAUSNER,** Consultant to The Martin Co.; **J. G. MORSE,** Nuclear Div., The Martin Co.; and **W. G. RAUCH,** U.S. Office of Naval Research

1958, 362 pages, $10.50

The changes that radiation produces in metals, ceramics, plastics and a wide variety of other materials are thoroughly covered in this momentous new book. It contains the papers delivered at the radiation effects colloquium jointly sponsored by the Office of Naval Research and The Martin Company at Johns Hopkins University in March 1957.

Twelve leading authorities analyze the results of their own actual experiments with various materials. Solid state physicists classify fundamental and qualitative effects according to type. Metallurgists and chemical engineers make a quantitative evaluation of radiation effects on physical properties. The book also includes current concepts of radiation effects and discusses experimental approaches to radiation studies.

The outstanding authorship, and the subject's timeliness and importance establish this book as a milestone in technical literature. An extensive bibliography brings together the enormous amount of literature on the subject from every part of the world.

CONTENTS AND CONTRIBUTORS:

Defects in Solids and Current Concepts of Radiation Effects—G. J. DIENES, Brookhaven National Laboratory.
Experimental Approaches to Radiation Studies—Radiation Sources and Desimetry—J. C. WILSON, Oak Ridge National Laboratory.
Radiation Effects on Physical and Metallurgical Properties of Metals and Alloys—E. S. BILLINGTON, Oak Ridge National Laboratory.
Influence of Radiation Upon Corrosion Behavior and Surface Properties of Metals and Alloys—M. SIMNAD, General Atomics.
Effects of Radiation on Electronic and Optical Properties of Inorganic Dielectric Materials—R. SMOLOCHOWSKI, Carnegie Institute of Technology.
Effects of Radiation on Semiconductors—H. Y. FAN and K. LARK-HOROVITZ, Purdue University.
Cores, Liquid Coolants and Control Rods—C. E. WEBER, General Electric Co. (Knolls Atomic Power Laboratory).
Moderators, Shielding and Auxiliary Equipment—G. R. HENNIG, Argonne National Laboratory.
Experimental Techniques and Current Concepts—Organic Substances—M. BURTON, University of Notre Dame.
Effects of Radiation on Behavior and Properties of Polymers—A. CHARLESBY, Tube Investments Ltd., Cambridge, England.
Kinetics of the Gamma-Induced Graft Copolymerization of Vinyl Acetate to Teflon—A. J. RESTAINO, Nuclear Div., The Martin Co.
Bibliography—H. FRIEDEMANN.

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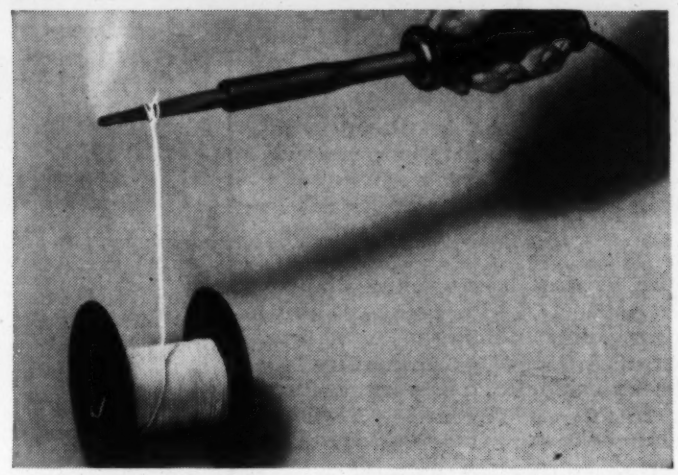
HOW TO SOLVE PRODUCT DESIGN PROBLEMS WITH

GE SILICONE IDEAS

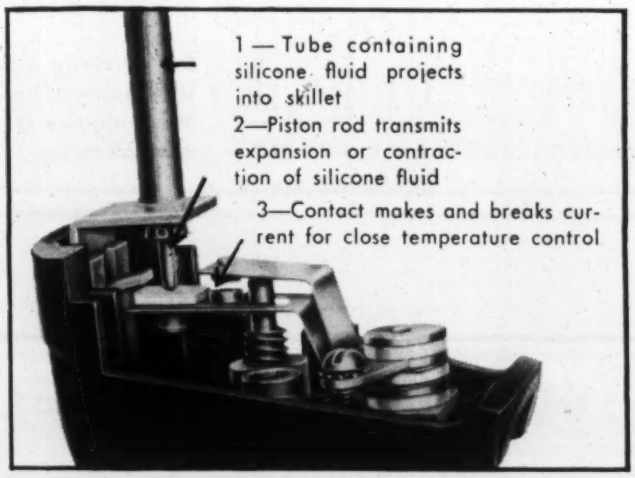
Silicone rubber for wire insulation adds improved physical properties to excellent electrical properties

Always valued for its high performance electrical characteristics at high temperatures, silicone rubber insulation for wire now has improved physical properties. A true elastomer, GE silicone rubber is suitable for thin wall (.012") wire construction, does not tend to cold flow under clamps, can be bent double without cracking, stays flexible down to —150°F.

Even when exposed to a direct flame, G-E silicone rubber still insulates, won't release toxic fumes. Withstands current overloads of 300%-400%, provides a safety margin for intermittent high temperature operation in Class B equipment. Excellent dielectric strength stays high throughout life; service to 500°F—and to 600°F for shorter periods. Features high ozone, moisture and weather resistance, long shelf life.



No damage occurs when you wrap silicone rubber insulated wire around a hot soldering iron, proof of silicone rubber's remarkable heat resistance.



New appliance thermostat uses silicone fluids for faster, closer temperature control

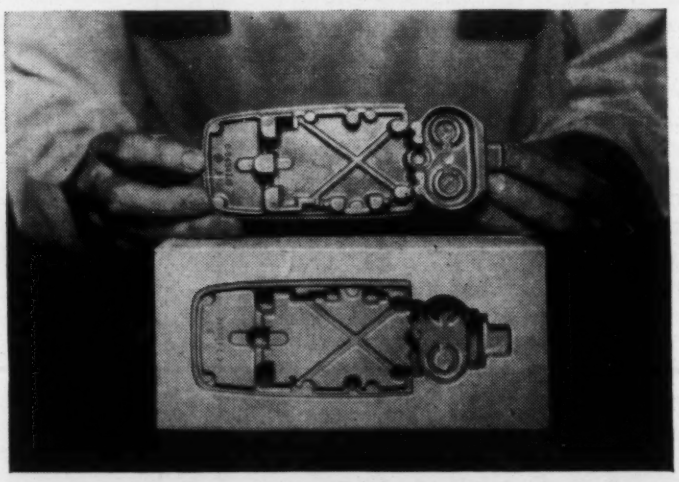
General Electric silicone fluids, because of their high coefficient of expansion and thermal stability, make possible the extremely accurate temperature control provided by the new G-E appliance thermostat. Reaction time is faster than with bimetallic elements; cost fully competitive.

This is only one example of creative engineering with G-E silicone fluids. Their unique properties—small change in viscosity with temperature, chemical inertness, excellent resistance to shear, oxidation and high-temperature breakdown—make them ideal for such applications as dash pots, vibration dampers, heat transfer fluids, fluid transmissions, etc.

New silicone rubber cures without heat, keeps physical and electrical properties to 600°F

Need to seal or caulk metal glass or plastic parts? Encapsulate or pot delicate assemblies? Mold silicone rubber parts in place? Patch or repair rubber parts? Need a flexible, heat resistant, accurate, self-releasing mold for low-cost plastic tooling or model making?

New G-E RTV (room temperature vulcanizing) silicone rubber will do all this and more. Cures without voids at room temperature in any time you select up to 48 hours. Stable up to 600°F. Tough, elastic, bonds well to primed surfaces. Has good resistance to fluids and fuels. Viscosities from very pourable to spreadable. Solvent free—shrinks less than 0.2% while curing. Write for technical data. Samples available for evaluation—just give us a brief description of your application.



Sample mold of complex part reproduced exactly, including undercuts. RTV cures without voids, without shrinkage.

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Section D10, Silicone Products Dept.
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Custom grades of graphite are regularly formulated by Graphite Specialties Corp., and furnished in extruded, molded and machined shapes to close tolerances to meet a wide range of difficult applications . . . *OR* GSC may be able to provide one of their many existing formulations to meet your requirements.

GRAPH-I-TITE: A collection of unique properties in one material, so valuable for such a wide diversity of uses, that GRAPH-I-TITE is furnished in two grades in standard sizes of rod and tube, as well as machined shapes. GRAPH - I - TITE possesses uniform high density . . . low permeability . . . immunity to thermal shock . . . resistance to corrosion at extremely elevated temperatures . . . and is not wetted by molten metals.

CARBO-TITE: Similar to "Graph-i-tite" except a carbon, rather than graphite base, and Carbo-tite is as hard as glass, and features a relatively *low* rate of thermal conductivity.

NUCLEAR: Purity grades to specified density for lowest neutron-capture cross section; highest scattering cross section for moderator, fuel elements, structural parts and piping and related equipment.

METALLURGICAL: Custom shapes and grades of graphite for special molds, dies, crucibles, boats, etc., for the chlorination of metals and other difficult applications.

MISSILES & ROCKETS: Recent developments make special grades of graphite particularly promising for nose cones, rocket nozzles and similar high temperature, high erosion applications.

MECHANICAL: Grades available with specified properties including temperature resistance to 5700°F., hardness to 5+Mohs for bearings, seal rings, seats, etc.

FURNACES: In addition to graphite components for resistance and induction furnaces, Graphite Specialties Corp. designs, manufactures and installs complete ultra-high temperature furnaces for heating requirements as high as 5700°F.

CHLORINE HEATERS: Special furnace development has led naturally to manufacture of what is believed to be the first practical type of chlorine heater for any temperature requirement to 5700°F.

Write to GRAPHITE SPECIALTIES CORP., 64th & Pine Ave., Niagara Falls, N. Y.

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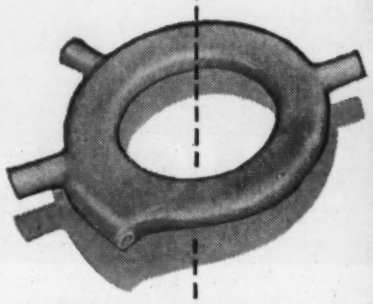
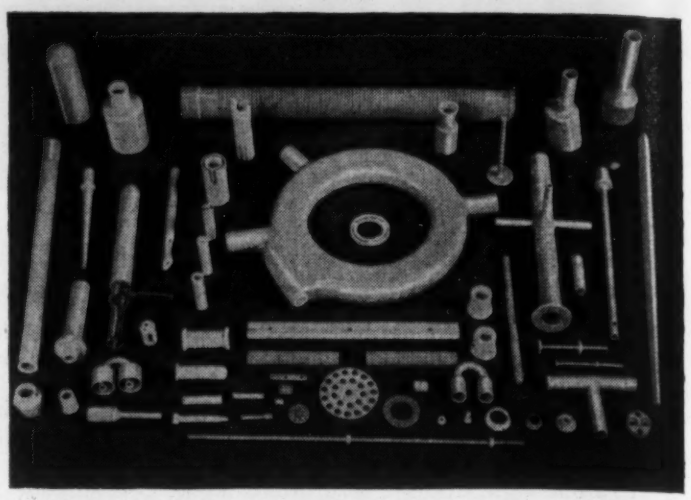


may be your ANSWER



Heat, abrasion, corrosion, chemical action, or other deteriorating factors present on your project? McDanel specially-developed ceramics could be the answer. Scientists, physicists, research and development engineers are applying McDanel ceramics to a wide variety of difficult applications with good success. Our engineers develop special dies, designs, even new processes to suit your particular need. Try ceramics.

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Or, if this isn't your own copy and you would like one

See page 481 for complete details

THIS IS GLASS

a bulletin of practical new ideas *from Corning*

How to get ahead with infrared

Fact: Every object whose temperature is above absolute zero (−273°C.) radiates infrared energy.

Additional fact: Considerable effort has been poured into developing mechanisms for detecting and utilizing infrared.

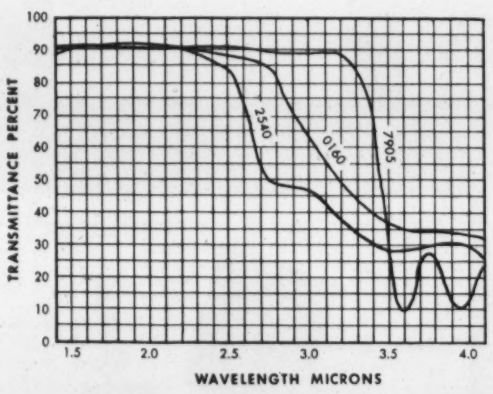
Among the more dramatic have been numerous devices for the military—items used for *target detection*, *missile guidance*, and *mapping*.

These tasks were once the unchallenged province of radar, though infrared is *older*, having been used after World War I in some experimental aircraft spotting. And while radar was the *big* weapon in World War II, the Germans used infrared both to supplement it and to counter Allied chaff.

Since then infrared technology has advanced rapidly. Today it is reported to be *less* expensive, *less* complex, and *more* discriminating than radar for some applications.

Our interest in infrared techniques centers on optical materials and design. Historically, *glass* has been *the* approach to selective handling of varied forms of radiant energy. Today, special glasses still hold the key to such control.

For example, three special Corning glasses are eminently suited to infrared transmission.



Infrared transmitting curves for three Corning glasses are shown for the 1.5 to 4.0 microns range.

Glass 0160, a crystal white form, can be made into flat plates, pressed, or blown. Glass 2540 is red and is stocked in flat plate *only*.

The third glass is 7905, one of the 96% silica glasses from which VYCOR brand products are made. Along with its infrared talent, this glass has: (a) capacity to operate continuously at high temperatures; (b) exceptional resistance to chemical attack; (c) ability to stand up to thermal shock.

(Note: Other 96% silica glasses share these characteristics but possess different, though equally useful, *optical* properties.)

Suggestion: If infrared maneuvering is one of your "hot" problems, write for details on the three glasses mentioned. Or, if the other diverse talents of the VYCOR group of glasses seem attractive, ask for Bulletin B-91. It provides all the pertinent data, plus facts on applications.

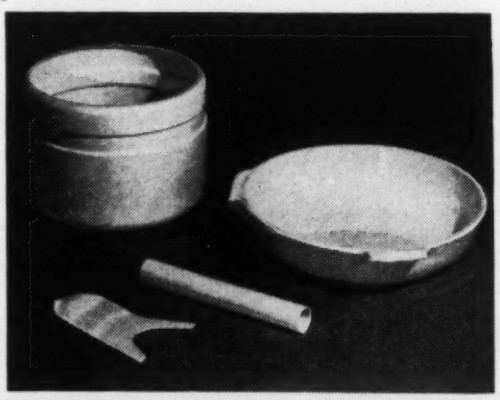
Small fanfare for a BIG development

Lighter than aluminum . . . stronger than tempered plate glass . . . harder than high carbon steel.

More? Electrical properties compare favorably with the best ceramics; coefficient of expansion can be positive, negative, or zero; stays rigid at temperatures that warp steel and melt copper; immune to the corrosive destruction of many chemicals.

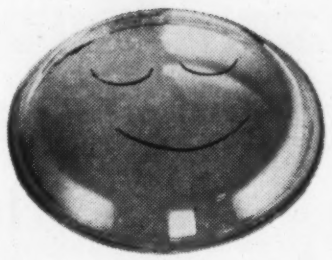
What is it? PYROCERAM—the trademark for Corning's new *crystalline materials* made from glass.

Aside from their many remarkable properties PYROCERAM materials offer this important advantage: they can be worked by many *conventional* glass forming processes. To wit:



PYROCERAM, Corning's new crystalline material can be worked by many techniques. Large dish was blown; shallow dish, pressed; tube, drawn; and blade made by investment casting.

First commercial application for these revolutionary new man-made materials is in nose cones for guided missiles. What else? Send us your ideas. Also ask for PYROCERAM Progress Report No. 2. It compares four forms of PYROCERAM with four glasses, three ceramics, and five metals. Other reports will follow.



Easy as pie

Take a pie plate. But make sure it's PYREX brand.

Remove the usual household markings and modify the shape just a bit. *Voilà!* No longer do you have a kitchen utensil. Instead? A *right*-sized, *right*-shaped *window*. For? Ovens, washers, dryers.

This metamorphic approach to component design and procurement offers all the advantages of Corning's long experience in mass production.

For example, the appliance maker who uses the pie-plate-like window gets a reliable, economical supply source—*without* the time and money usually required for development, expansion, and tooling up.

And, he gets a *rugged* window that he can *install* and *sell* with confidence.

The adapting or making something new from an already-existing item is a wide open field at Corning since some 40,000 available products are considered *standard!*

Still, there's no denying that *many* of our most successful ventures have resulted from combining *our know-how* with customer skill and need. Result? *Custom* design and fabrication of many, many components and products.

Want to try your hand? You might start by perusing "This Is Glass," a well illustrated primer. Or outline in a memo to us what's on your mind. At least put these informative brochures in your ready-reference file: B-83 (revised)—"Properties of Selected Commercial Glasses"; IZ-1—"Glass, its increasing importance in product design." One, or all *free*.

Corning means research in Glass

CORNING GLASS WORKS, 50-10 Crystal Street, Corning, N. Y.

Please send me the following material: "This Is Glass" ☐; Bulletin B-91—"Vycor Brand Industrial Glassware" ☐; PYROCERAM Progress Report **No. 2** ☐; B-83 (revised)—"Properties of Selected Commercial Glasses" ☐; Infrared Transmitting Glasses ☐; IZ-1—"Glass, its increasing importance in product design" ☐.

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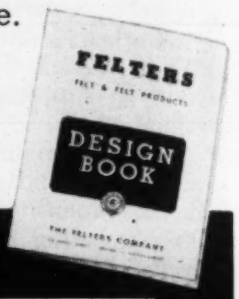
SPECIAL FELT TREATMENTS Increase Life, Improve Properties for Seals, Filtering and Cushioning

Never before has FELT been able to provide such a wide range of properties — for such applications as seals, filtering and cushioning! And Felters is continually experimenting with many combinations to provide designers with more and more versatility in felt, including use of the newest synthetics and plastics.

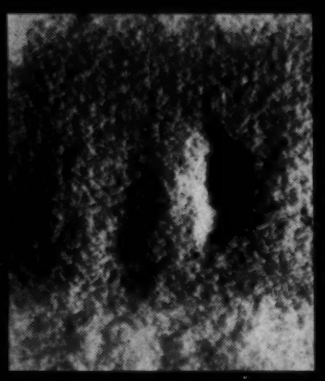
What do you want FELT to do?
Felters has pioneered in producing felts which have unusual properties for special applications.

Let Felters help you make felt do more jobs, more efficiently — with special treated or standard Cut Parts. Specific technical service is available from any Felters office.

Send for Design Book . . .
for a complete digest of basic data on felt properties and uses.



Felters' Nylon-treated all wool Felt provides extra wear, superior resistance to scuffing, abrasion and friction. Extra strength without increased density. Each fiber encased in protective sheath of nylon. Porosity and resistance of felt unaffected. Wyzenbeck Wear Test of 6,000 strokes on Untreated versus Nylon Resin Treated Swatches demonstrates the difference.



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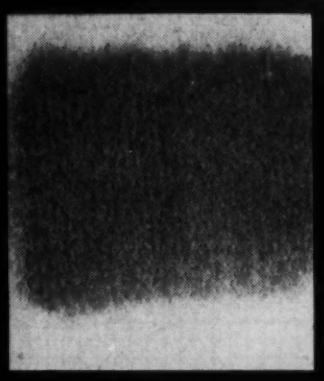
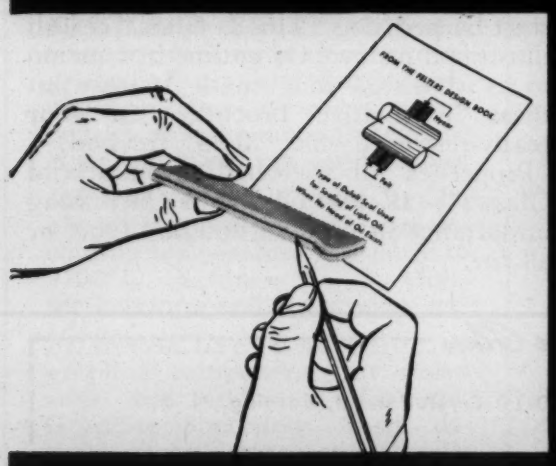
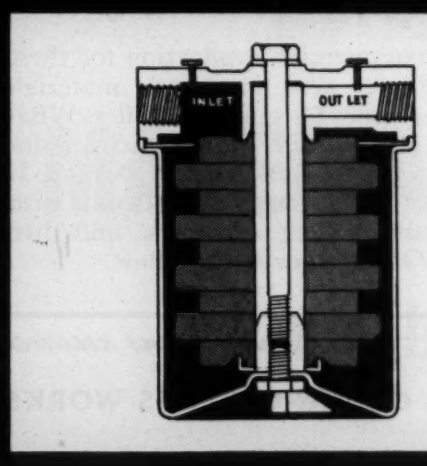
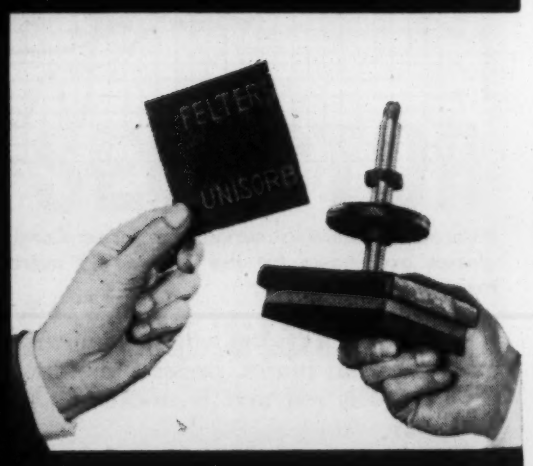


Treated







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KENNAMETAL*

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TUNGSTEN CARBIDES • TITANIUM CARBIDES

PRODUCT	PROPERTIES	TYPICAL APPLICATIONS
Kennametal (tungsten-base carbides)	YME of 60 to 90 million psi. Compressive strength higher than virtually all melted and cast or forged metals and alloys. Kennametal outwears steel up to 100 to 1. Impact strength in the range of hardened alloy steels of very much lower hardness and compressive strength. Thermal expansion about half that of steel. Compositions to withstand one or various combinations of destructive agents such as abrasion, corrosion, galling, impact, and erosion, or meet specific requirements as to stiffness, strength and weight.	Metalworking and mining tool cutting edges. Die inserts. Seal rings. Integrator discs. Needle valves and cones. Compressor liners. Pulverizing hammers. Abrasion resistant knives, blades, shears. Boring bars. Spray orifices. Balls and seats for oil well pump valves.
Kentanium* (titanium-base carbides)	Superior strength and abrasion resistance at temperatures 1800°F. and up . . . temperatures that rapidly destroy conventional carbides or high temperature cast alloys. Can be subjected continuously to operating temperatures up to 2200°F., and up to 5000°F. for short periods. Greater resistance to thermal shock than ceramics. Highest stiffness-to-weight ratio of any material . . . approximately ⅔ the weight of steel. YME up to 60 million psi.	Sensing elements for high temperature thermostatic controls. Spinning tools for hot metals. Flash-trimming tools. Turbine components. Balls for pump check valves. Nuclear reactor equipment. Rotary seal rings. Hot rod mill guide inserts. Anvils for spot welding. Balls for hot hardness testing.
Pure Carbides	Low binder content. High melting point.	Crucibles. Acid resistant parts. High temperature furnace parts.
Heavy Tungsten Alloys	Nominal Density: 16.5 to 18.7 gm/cc. Machinability: Good. Tensile Strength: 40,000 to 90,000 psi. Corrosion Resistance: Excellent. Readily brazed with Easy-Flo No. 3 Compound. Available as bars, rods, rings, discs, special shapes.	Counterweights. Radioactive shielding. Isotope containers. Atomic watch shielding. Shielding — cobalt and X-ray medical equipment. Rotational parts — flywheels, governors, gyroscope components. Electrical contactors for high current heavy duty applications.
Niobium	Metal — 99.8% grade. Granules, arc melting electrodes, bar, strip, foil. Metal — 99.5% and 98.5% grades. Powders, granules, arc melting electrodes. Oxide — 99% and 99.5% grades. Fine powder.	Bars: Nominal size ½″ x 2″ x 19″. Other sizes available. Strip, Foil: .001″ to .100″ thick, up to 4″ wide. Powders: 20 to 80 mesh. Granules: 3/16″ to 40 mesh.
Tantalum	Metal — 99.9% (capacitor) grade. Solid form — strip, bar, foil, wire. Metal — 99.5% grade. Granules. Metal Powder — 99.8% grade. Fine powder. Oxide — 99% grade. Fine powder.	Bars: Nominal size ½″ x 2″ x 19″. Other sizes available. Strip, Foil: .001″ to .100″ thick, up to 4″ wide. Wire: From .005″ to .030″. Granules: 20 mesh. Other sizes and grades available. Powder: 200 mesh. Other sizes available. Oxides: In analyses and particle sizes to meet specific requirements.
Kenspray (hard surfacing material)	Powder applied by hand or mechanically-held metal spraying equipment. May be successfully applied to irregular shapes or flat surfaces. Only thin coating required (from .010″ to .090″). Conserves material, provides uniform surface. After spraying application, part is heated to fuse the hard surfacing deposit to its base. For close tolerances, part may then be ground with silicon carbide wheels.	Machine components and equipment for food, chemical, petro-chemical, other processing industries . . . Cams, valve seats, sleeves, shafts, dies, guides, jigs, process rolls, wear strips, valve plugs and bodies, grain mill hammers, pump parts, agricultural equipment.
Kenplate (hard surfacing material)	Factory assembled as small, hexagonal plates in a uniform mating pattern on flexible woven-glass backing. Plate thicknesses from .062″ to .250″ in two hex sizes. May be applied by standard epoxy bonding, silver soldering, conventional brazing.	Wear plates in processing equipment. Liners for ball mills, inclined chutes for abrasive materials. Centrifuge surfaces. Slide surfaces, guide rails for materials handling equipment.

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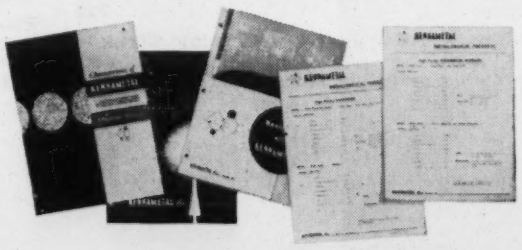

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Corrosion Inhibitor. Solvay Process Div., Allied Chemical Corp., 17 pp, illus. Use of sodium nitrite in corrosion prevention. **215**

Zinc, Cadmium Finishes. Allied Research Products, Inc. Describes Iridite finishes for zinc and cadmium in chromium-like, olive green, iridescent and other colors. **216**

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Blackening Metals. Enthone Inc., Div. of American Smelting & Refining Co., 8 pp, illus. Characteristics and operating data for a finishing process used to blacken steel, copper, brass and zinc. **220**

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Ultrasonic Cleaning. Branson Ultrasonic Corp., 24 pp, illus. Applications, descriptions, features, capabilities and specifications for ultrasonic cleaning equipment. **255**

Conversion Coatings. Chemical Corp., 42 pp. General description, bath make-up and specifications for a number of conversion coatings for zinc and cadmium. **222**

Polyvinyl Plastisols. Chemical Products Corp., 16 pp. Advantages, uses and properties of the company's polyvinyl plastisol coating and molding compounds. **223**

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Zinc Phosphate Coatings. Detrex Chemical Industries, Inc., 8 pp, illus. Describes phosphate coatings for protection of paint finishes under severe corrosion conditions. **225**

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Sillicone Coatings. Dow Corning Corp., 4 pp, illus., No. 8-601. Properties and performance data on silicone treated papers. Contains samples of coated kraft, glassine and parchment. **227**

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Rhodium Electroplates. Sel-Rex Corp., Precious Metals Div., 20 pp, illus. Properties and uses, plating formulations, and operating instructions for a rhodium electroplating process. **246**

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Phosphate Coating. Turco Products, Inc., 4 pp, No. 108-12. Application data, properties and uses of a coating material for simultaneous cleaning and light phosphating of iron, steel and zinc. **252**

Protective Coatings. U. S. Stoneware Co., Plastics & Synthetics Div., 30 pp, illus. Properties, uses, limitations and cost of specialized protective coatings. **253**

Hard Facing Alloys. Wall Colmonoy Corp., 4 pp, illus., No. 5. "Alloy News" cites improved product design and longer service life of gears, tubing and pipe that have been treated with hard facing alloys. **254**

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PROPERTIES OF MATERIALS

Finishes and Coatings

	PAGE
Hard Coatings and Surfaces	258
Chemical Conversion Coatings	259
Chromium Electroplates	260
Nickel Electroplates	262
Cadmium and Zinc Electroplates	264
Sprayed Metal Coatings	265
Mechanical Finishes	266
Organic Coatings	267
Porcelain Enamels	270
Clad and Precoated Metals	272
Advertisements	278
Suppliers' Literature	256

Hard Coatings and Surfaces

Type ↓	Method of Application	Basic Metals That Can Be Coated	Nature of Hard Surface	Usual Thickness Range	Hardness	Major Characteristics
Hard Facing	Hard alloys applied by variety of welding processes, including gas metal arc and atomic hydrogen arc. Surface of metal brought to melting point of hard facing alloy. Parts may require preheat at 700–1200 F	Practically all ferrous metals. Some high-melting nonferrous alloys	Variety of ferrous and nonferrous alloys	1/16–1/4 in.	Wide range up to Rockwell A90, depending on alloy used	High hardness combined with varying degrees of resistance to abrasion impact, corrosion and heat, depending on alloy used
Carburized Surface	Carbon in solid, liquid or gas form introduced into metal surface by heating both in contact at temperatures above transformation range, generally 1450–1750 F	Carbon and alloy steels low enough in carbon content (<0.45%) to take up that element readily	Case high in carbon	0.005–0.25 in.	Approx Rockwell C62–64	High strength and toughness in core can be combined with extreme surface hardness
Nitrided Surface	Nitrogen introduced into surface by heating metal in contact with ammonia or other nitrogeneous material at 930–1050 F	Primarily special nitriding steels. Also medium carbon steels containing chromium and molybdenum, stainless steels, some cast irons	Case containing nitrides of various alloying elements	0.005–0.030 in.	Approx Rockwell C63–64 for molybdenum steel; 15N92 for 416 stainless and Nitralloy 135	High wear resistance, retention of hardness at elevated temperatures. Good resistance to certain types of corrosion
Cyanided or Carbonitrided Surface	Carbon and nitrogen introduced into surface by heating metal in liquid cyanide (cyaniding) or in carbonaceous and nitrogeneous (carbonitriding) both at 1200–1600 F	Same steels as used for carburizing	High carbon case containing nitrides	0.003–0.020 in.	Rockwell A80–81 for SAE 1010 steel	In general, same as for carburized cases
Siliconized Surface	Silicon introduced into surface by heating metal in contact with silicon carbide and chlorine at 1700–1850F	Low carbon(<0.25%), low sulfur (<0.04%) steels	Alloy case containing up to 14% silicon	0.005–0.010 in.	Rockwell B80–85	High resistance to wear, heat, corrosion
Chromized Surface	Chromium introduced into surface by heating metal in contact with chromium-containing powdered compound at 1500–1900 F	Low and high carbon steels, many alloy steels,stainless steels, tool steels, cast iron, iron powder parts	High chromium stainless steel or chromium carbide, depending on metal composition	0.5–2 mil	1600–2300 Vickers for chromium carbide case	High resistance to wear, abrasion, corrosion
Flame Hardened Surface	Surface structure changed by heating surface only with oxyacetylene flame above transformation range, followed by quenching	Any steel that can be hardened by conventional methods	Hardened surface structure. No change in chemical composition	0.06–0.25 in.	Max hardness depends on carbon content of base metal	High hardness, resistance to wear and abrasion
Induction Hardened Surface	Surface structure changed by heating surface only by means of electrical induction above transformation range, followed by quenching	Medium carbon steels, gray cast iron, pearlitic malleable and nodular cast irons	Same as flame hardened surface	0.015–0.125 in.	Max hardness depends on carbon content of base metal	Same as for flame hardened surface
Chromium Plate	Electrodeposition of chromium	Iron, steel, copper, nickel, zinc, aluminum, magnesium, titanium, brass	Chromium	Approx 1 mil max	Up to 1000–1025 Brinell	High hardness, excellent corrosion resistance, low coefficient of friction, nongalling and nonwetting
Nickel Plate	Electrodeposition of nickel	Iron, steel, copper, zinc, aluminum, magnesium, brass	Nickel	Up to 1/4 in.	150–800 Vickers	High wear, corrosion resistance
Rhodium Plate	Electrodeposition of rhodium	Most metals, including gold, silver, electrical contact materials	Rhodium	0.001–1 mil	540 to 640 Vickers (20-gm load)	High hardness and wear resistance, attractive appearance
Hard Anodized Coating	Surface converted to metallic oxide or other inorganic compound by electrochemical process in which base metal is made anode in electrolyte	Most aluminum alloys and magnesium	Case consisting of oxides or other inorganic compounds of the base metal	Approx 1–5 mils	Difficult to assess by conventional methods	Better resistance to abrasion, erosion and corrosion than base metal
Sprayed Coating	Metal or ceramic layer applied by spraying molten or semimolten particles which fuse, cool and solidify on surface. Surface temperature ranges up to 800 F	Most commonly used metals	Bronze, various irons and steels, molybdenum, aluminum or zirconium oxide, zirconium silicate, tungsten carbide	Metals: up to 1/8 in. Ceramics: 0.005–0.050 in.	Up to 1350 Vickers for tungsten carbide	Extremely wide range of surface properties, depending on coating material

Chemical Conversion Coatings

Purpose and Type ↓	How the Coatings Compare	Metals That Can Be Coated*									
		Aluminum	Cadmium	Copper	Iron	Magnesium	Silver	Steel	Tin	Titanium	Zinc
To Improve Paint Bonding											
Phosphate	Rough crystalline structure provides excellent paint adhesion. Better paint bond than chromate coatings. Corrosion confined to limited area when paint film damaged	X	X		X	0		X	0		X
Chromate	Provides high corrosion protection because of nonporous structure. Paint adhesion generally not as good as with phosphate	X	X	0	0	X	0	0	0		X
To Improve Corrosion Resistance											
Anodic	Provides equal or better corrosion protection—at higher cost—than chromate	X				X					0
Chromate	Generally provides much better corrosion resistance than phosphate. Nonporous structure acts as moisture barrier. If coating is broken, inhibiting action of soluble chromate retards corrosion of basis metal	X	X	X	0	X	0	0	0		X
Phosphate	Not generally used alone for corrosion protection. When treated with oils, waxes or stains, however, it provides good protection, especially on ferrous surfaces	X	0		X			X	0		X
Oxide and Other	Do not provide as much protection as other conversion coatings, but cost is lower	0	0	0	0			0			0
For Decoration											
Chromate	Available in wide variety of natural and dyed colors. Colors are not as light-fast as in colored anodic coatings	X	X	X	0	X		0	0		X
Anodic	Can be colored with a large variety of dyes and pigments. Underlying metal can be used to impart attractive metallic sheen. Sealing required	X				X					0
Phosphate	Little decorative value except when painted	X	X		X	0		X	0		X
Oxide and Other	Black and blue-black coatings widely used to decorate ferrous, zinc and cadmium surfaces. Considerable number of colors producible on copper and aluminum	X	X	X	X			X			X
To Aid In Cold Forming											
Phosphate	By preventing metal-to-metal contact, lubricated coating facilitates deep drawing, cold heading, extrusion, and wire and tube drawing	X			X			X			X[b]
Oxide and Other	Special coatings have been developed for titanium									X	
To Improve Wear Resistance											
Phosphate	Maintains continuous oil film between bearing surfaces; prevents welding of surfaces under load				X			X			
Anodic	Hard anodic coating with greater thickness and weight than conventional anodic coatings increases wear and abrasion resistance	X				X					

*X—Metals most commonly treated for purpose listed. O—Metals less commonly treated. [b]Electroplates.

Chromium Electroplates

Types of Plates

Chromium electrodeposits consist of two principal types: decorative and hard chromium plates, and their modifications. Both principal types are deposited from the same plating baths and are distinguishable only by their different thicknesses.

Decorative chromium. Decorative plates are quite thin (0.01-0.02 mil), are usually deposited over a nickel plate, and are used primarily because of their bright, nontarnishing finish.

Some typical applications of decorative chromium plate are: automobile trim and hardware, plumbing fixtures, household appliances and hardware, sanitary fixtures, tools and jewelry.

Hard chromium. These coatings are comparatively thick (0.1 to 15 mils) and are used primarily in engineering applications because of their extreme hardness, low coefficient of friction, chemical resistance, and nongalling and nonwetting properties. Undercoats of nickel or copper are sometimes used for added corrosion resistance.

Applications of hard chromium plate are quite extensive. Some principal applications are gages, tools and machine tool parts—both new parts and worn parts to be salvaged. Taps, drills, saws, milling cutters and burnishing tools have been successfully plated. Molds for plastics and rubber are plated to reduce wear and sticking and to improve product appearance. Gun barrels, pump shafts, engine cylinders, drawing dies, calender rolls and engraving dies are other applications.

Porous chromium. This type of plate is essentially a hard chromium plate containing carefully controlled pits or channels designed to improve the lubrication properties of bearing surfaces. Plates range in thickness from 3 to 15 mils. Beneath its outer surface the plate is no more porous than ordinary hard chromium plate.

Porous chromium plate consists of three principal types: mechanical, pit and channel. The mechanical type is produced by hard chromium plating and subsequently polishing a roughened, cut or engraved basis metal. The polished tops of the grains form the bearing surface and the depressions between the grains hold the lubricating oil. The pit and channel types are produced by chemical or electrochemical etching of the chromium deposit. Plating conditions are controlled to produce latent chromium deposits predisposed to the development of a particular size and type of network pattern during etching.

The pit or pocket type of porous plate is generally used on diesel engine cylinders and industrial gasoline and gas engines, pumps and compressors. The channel type of deposit is generally used on aircraft cylinders. Thickness and porosity of both types of deposits depend on the size and type of engine.

Crack-free chromium. Crack-free plates, deposited in self-regulating baths, have recently achieved considerable importance. These plates have two principal advantages: 1) their dense, uniform, crack-free structure provides excellent resistance to corrosion and thermal shock, and 2) self-regulation of the bath practically eliminates maintenance problems. In many applications the coating can be deposited directly on the basis metal without prior nickel or copper plating. Deposits are producible in a bright or gray, matte finish. Applications for crack-free plate are generally the same as for decorative and hard chromium plates.

PHYSICAL AND MECHANICAL PROPERTIES

Density, lb/cu in.	0.25
Melting Point, F	3452
Ther Cond, Btu/hr/sq ft/°F/ft	157.3
Specific Heat, Btu/lb/°F	0.1039
Coef of Ther Exp, per °F	14.6×10^{-6}
Reflectivity, %	
Visible Light	62-72
Ultraviolet Light	55-70
Infrared Light	62-88
Elec Res (82 F), microhm-cm	
As Deposited	50-60
After Annealing	13
Hardness (Brinell)	1000 max
Sliding Coef of Friction	
Cr-Plated Steel vs Cr-Plated Steel	0.12
Cr-Plated Steel vs Babbitt	0.13
Cr-Plated Steel vs Steel	0.16

Basis Metals Plated

Aluminum and its alloys
Copper and its alloys
Iron and steel
Magnesium alloys
Nickel and its alloys
Titanium and its alloys
Zinc and its alloys

Treatment After Plating

Recent work indicates that heat treatment may not be desirable in applications where fatigue is a factor. In some applications, however, heat treatment may be required to relieve strains caused by occluded hydrogen. For example, hardened high carbon steel parts of thin cross section, such as steel tools, generally require heat treatment after plating. Parts are placed in an oil bath or oven at 250-350 F for 1 to 3 hr. Immersion in boiling water for extended periods has also proved effective.

Basis Metal Pretreatment

Decorative plate. In general, bright nickel work that does not require buffing can be placed, still wet, directly in the chromium plating solution. Buffed surfaces, however, must be cleaned to remove grease, dirt and oxide films. Cleaning is performed as follows:

1. Electrolytic alkaline cleaning with basis metal as cathode. Treatment performed at 6-12 v and 175-200 F long enough to remove dirt and grease.
2. Warm water rinse (120 to 160 F).
3. Cold water rinse.
4. Acid dip at room temperature to remove surface oxide. Treatment can be performed in sulfuric acid (20% by vol) solution; in muriatic acid (30-50%) solution; or by using basis metal as cathode (4-6 v) in electrolytic sulfuric acid (5%) solution.
5. Cold water rinse.

Hard chromium plate. Basis metal pretreatment is especially important for hard chromium plates since the coating does not fill in pits and scratches and tends to reproduce the surface on which it is deposited. Though no definite sequence of operations can be given for all types of work, the following pretreatment is typical for ferrous surfaces:

1. Preliminary grinding to remove scale, pits and scratches. (This step is not required for smooth surfaces.)
2. Preliminary cleaning by vapor degreasing or washing in petroleum spirits to remove oil or grease.
3. Electrolytic cleaning in hot alkali cleaner.
4. Cold water rinse.
5. Electrolytic etch to remove light rust and other iron compounds, and to produce a slightly roughened surface that will promote adhesion of chromium. Sulfuric or chromic acids are most commonly used; if shape of parts causes entrapment of sulfuric acid with consequent danger of contaminating chromium plating bath, chromic acid etch may be preferred. Parts may be transferred directly from chromic acid bath without rinsing.

Etching is sometimes produced in chromium plating bath by reversing current so that work is made anodic. After etching (about ½-1 min), current is reversed and plating started. Thin oxide films can also be removed by dipping work in dilute sulfuric or hydrochloric acids. This method does not appreciably dull the luster of highly polished surfaces; however, it does not promote adhesion as well as other etches.

Plating Baths

Conventional chromium plating baths contain only two essential constituents: chromic acid and a sulfate catalyst acid radical. Successful deposition is determined by the weight ratio of chromic acid to sulfate; this ratio should be kept between 50:1 and 250:1, preferably at about 100:1. Too small a catalyst content can result in no deposition at all or else produce brown oxide stain. Similarly, too high a catalyst content produces a bath with poor or no throwing power. Two typical formulations are:

Concentrated		Dilute	
Chromic acid (CrO_3)	53 oz/gal	Chromic acid	33 oz/gal
Sulfate	0.53 oz/gal	Sulfate	0.33 oz/gal

The dilute bath has a slightly higher current efficiency than the concentrated bath. However, because of its lower conductivity, the dilute bath usually requires a higher voltage for a given current density. Also, because of its low sulfate content, the dilute bath is more sensitive to the addition or removal of catalyst from drag-in and drag-out.

A self-regulating high speed chromium plating solution is gaining wide acceptance, especially for high production decorative plating using automatic equipment. It consists of a proprietary solution containing mixed acid radicals which automatically regulate themselves. The high cathode current efficiencies and the bright plates produced at high current densities result in high plating rates—more than twice those of conventional solutions, it is claimed.

Thickness of Deposits

In general, thickness of plates for decorative applications ranges from 0.01 to 0.02 mil. Following are some typical thickness recommendations (in mils) for hard chromium deposits:

Drills	0.05-0.5
Reamers	0.1-0.5
Burnishing bars	0.5-3.0
Drawing plugs, mandrels	1.5-8.0
Drawing dies	0.5-8.0
Gages	0.1-1.5
Pump shafts	0.5-3.0
Rolls, drums	0.25-12.0
Hydraulic rams	0.5-4.0
Printing plates (engraved steel)	0.2-0.5

Nickel Electroplates

Commonly Used Plating Baths

Watts. The Watts type bath is the most commonly used plating bath and is very flexible with respect to composition, current density and temperature. The bath is used to obtain a decorative matte finish or a bright finish subsequent to polishing or buffing. It is also used to build up worn or mismachined parts that are subject to wear. Relatively thick deposits are used for electroforming and to prevent corrosion of steel pipe and other equipment used for the processing of chemicals, petroleum and foods. The baths are usually grouped into two classifications on the basis of operating pH:

	High pH	Low pH
Nickel sulfate, oz/gal	32	44
Nickel chloride, oz/gal	6	6
Boric acid, oz/gal	4	5
pH	4.5-6.0	1.5-4.5
Temperature, F	115-160	115-140
Current density, amp/sq ft	20-100	25-100

Advantages of the low pH bath (commonly known as the soft nickel bath or general purpose bath) over the high pH bath are: 1) higher current densities (resulting in increased output) can be used without causing deposit peeling or cracking; and 2) improved anode efficiency decreases nickel salt consumption. Disadvantages of the low pH bath are: 1) lower throwing power at low current densities; 2) tendency to pit at some points in the pH range; and 3) lower cathode efficiency.

Chloride-sulfate. This bath produces deposits with modified characteristics of the Watts type and all-chloride baths:

Nickel sulfate, oz/gal	26	pH	1.5
Nickel chloride, oz/gal	23	Temperature, F	115
Boric acid, oz/gal	5.3	Current density, amp/sq ft	25-100

The increased chloride concentration produces a smoother, finer grained, more easily buffed deposit with less tendency to pit than the Watts bath. The bath can also be operated at lower voltages and higher current densities at greater cathode efficiency. Advantages claimed over the all-chloride bath are a more ductile deposit, easier pH control, simpler purification, and compatibility with available organic brighteners.

Hard nickel. This bath is used primarily when a deposit is needed which is tougher and less liable to crack and peel than chromium and where the extreme hardness of chromium is not essential. Deposits possess high resistance to wear and corrosion and are adaptable to conventional machining practices. If a heavy deposit with an extremely hard surface is required, a dual layer of hard nickel followed by chromium can be used.

Nickel sulfate, oz/gal	24	pH	5.6-5.9
Ammonium chloride, oz/gal	3.3	Temperature, F	110-140
Boric acid, oz/gal	4.0	Current density, amp/sq ft	25-50

Uses

Because of their good corrosion resistance and favorable physical and mechanical properties, nickel electro-deposits are used in numerous and diverse applications. Principal among the applications for nickel electro-deposits are: 1) decorative and industrial corrosion resistant coatings in matte, semi-bright and bright finishes; 2) coatings to build up worn or mismachined parts; 3) electro-formed parts; and 4) coatings for nonconductors.

Basis Metals Plated

Aluminum and its alloys
Beryllium copper
Brass
Cast iron
Copper and its alloys
Inconel
Magnesium
Monel
Nickel (wrought and electrolytic)
Nickel-iron alloys
Nickel silver
Pewter
Lead-base alloys
Steel (carbon, nickel, tungsten and stainless)
Tin and tinplate

Thickness of Deposits

Decorative applications: up to 0.5 mil
Corrosive applications: 3 to 15 mils
Applications to improve wear resistance: 0.002 to ¼ in.

PHYSICAL AND MECHANICAL PROPERTIES

Density, lb/cu in.	0.322
Specific Gravity	8.9
Melting Point, F	2640
Specific Heat (32-212 F), Btu/lb/°F	0.11
Coef of Ther Exp (32-212 F), per °F	7.5×10^{-6}
Ther Cond (32-212 F), Btu/sq ft/hr/°F/in.	470
Elec Res (68 F), microhm-cm	7.0
Mod of Elast in Tension, psi	30×10^{6}
Tensile Strength, psi	
Soft Gray Deposits	51,000
Hard Bright Deposits	140-160,000
Elongation (in 2 in.), %	
Soft Deposits	30
Bright Deposits	10
Vickers Hardness	
Soft Deposits	150
Bright Deposits	475-525

RECOMMENDED BASIS METAL PRETREATMENT*

Basis Metal	Application		Sequence of Pretreatment Operations
	Decorative	Industrial	
Aluminum	X	X	Two general classes of pretreatment processes available: 1) application of immersion deposits (such as zincate process); and 2) variations of anodizing (such as phosphoric acid anodizing process)
Brass	X		Degreasing + cathodic and anodic alkaline cleaning + cold water rinse + hydrochloric acid dip + cold rinse
Brass		X	Degreasing + cathodic alkali ne cleaning + pumice scrub + cold rinse + nitric acid dip
Cast Iron	X	X	Degreasing + cathodic and anodic alkaline cleaning + cold rinse + anodic sulfuric acid treatment
Copper	X		Degreasing + cathodic and anodic alkaline cleaning + cold rinse + sodium cyanide dip + cold rinse + cold sulfuric acid dip + cold rinse
Copper		X	Degreasing + cathodic alkaline cleaning + pumice scrub + cold rinse + nitric acid dip + cold rinse
Copper Alloys		X	Degreasing + cathodic alkaline cleaning + pumice scrub + cold rinse + etch in cold solution of nitric-sulfuric-hydrochloric acid + cold rinse + dip in sodium hydroxide and potassium persulfate solution + cold rinse + short dip in 1% (by vol) sulfuric acid solution + cold rinse
Inconel	X	X	Degreasing + cathodic and anodic alkaline cleaning + cold rinse + treatment in acid nickel chloride solution
Monel	X	X	Degreasing + cathodic and anodic alkaline cleaning + cold rinse + anodic sulfuric acid treatment + cold rinse
Nickel (wrought)		X	Degreasing + cathodic alkaline cleaning + pumice scrub + cold rinse + anodic alkaline cleaning + cold rinse + anodic sulfuric acid treatment
Nickel (electrolytic)	X	X	Degreasing + cathodic and anodic alkaline cleaning + cold rinse + treatment in low pH Watts type or all-chloride nickel bath + cold rinse
Nickel-Iron Alloys	X	X	Degreasing + cathodic and anodic alkaline cleaning + cold rinse + anodic sulfuric acid treatment
Steels (carbon)	X		Degreasing + cathodic and anodic alkaline cleaning + cold rinse + hydrochloric acid dip + cold rinse
Steels (carbon)		X	Degreasing + cathodic alkaline cleaning + pumice scrub + cold rinse + anodic alkaline cleaning + cold rinse + anodic sulfuric acid treatment + cold rinse
Steels (nickel)	X	X	Degreasing + cathodic and anodic alkaline cleaning + cold rinse + anodic sulfuric acid treatment + cold rinse
Steels (stainless)	X	X	Degreasing + cathodic and anodic alkaline cleaning + cold rinse + treatment in acid nickel chloride solution
Steels (tungsten)	X	X	Degreasing + cathodic and anodic alkaline cleaning + cold rinse + anodic sulfuric acid treatment + cold rinse + treatment in acid nickel chloride solution (cathodic only)
Tin or Tinplate	X	X	Degreasing + cathodic and anodic alkaline cleaning + cold rinse + cyanide copper plating + cold rinse + acid ammonium citrate solution treatment + cold rinse
Zinc	X	X	Treatment in solvent degreaser or emulsion slush cleaner + soak cleaning + warm water rinse + anodic cleaning + cold water rinse + dip in 2% sulfuric acid solution + cold water rinse + copper plate + cold water rinse

* Basis metal surface should be smooth and free of scale and tarnish. Rapid transfer of parts from last pretreatment operation to plating bath is recommended.

Zinc and Cadmium Electroplates

Plate Characteristics

Zinc plates are inexpensive and have good resistance to many atmospheres and most soils. They provide galvanic protection for steel. Typical applications are switch boxes, conduit, and nuts and bolts. Zinc plates are also used as a corrosion resistant paint base. Zinc-plated steel sheet and strip are commercially available.

Resembling zinc plate in many of its properties, cadmium plate is sometimes considered to be competitive with it. However, it costs more and is generally restricted to those applications in which it is markedly superior to zinc. It provides sacrificial galvanic protection for steel, and is more easily applied than zinc to gray and malleable iron. It has less tendency to darken than zinc and is less subject to the formation of bulky white corrosion products. It also permits soldering with noncorrosive fluxes. A thin plate (up to 0.001 in.) is sometimes used as a base for zinc plate.

Cadmium is seldom used as a decorative plate. It has found widespread use for coating electronic chassis, aircraft engine parts, switchgear and hardware. In severe marine applications, cadmium generally stands up better than zinc, though the difference is not as clear-cut as was once believed. Zinc has proved superior in most industrial environments, but cadmium plates have outperformed zinc in humid indoor atmospheres.

The potential difference between cadmium and iron is less than that between zinc and iron. Therefore cadmium does not cathodically protect as large an area of exposed iron as does zinc. It is possible in some environments that the potentials of cadmium and iron may reverse, permitting pinhole corrosion of the iron.

Zinc Plating Baths

Acid bath. The acid bath has poor throwing power but a high plating rate and low operating cost. It is largely used for plating steel wire and strip. Baths may be of the sulfate, sulfate-chloride or chloride type. Zinc sulfate is the principal salt used. At high acidities considerable hydrogen may be deposited producing pitted or spongy deposits. Therefore it is common practice to regulate acidity in the range of 3.5 to 4.5 pH by using a buffer such as sodium acetate, or aluminum chloride or sulfate.

Unmodified acid zinc baths normally produce coarse-grained deposits. To obtain a more refined structure, and to improve throwing power, additional agents are added. These are usually organic substances. Typical operating conditions in an acid bath are: temperature, 72-85 F; current density, 20-30 amp per sq ft (still bath) or 20-100 amp per sq ft (agitated bath).

Alkaline bath. The alkaline, or cyanide, zinc baths have excellent throwing power and can provide a variety of deposits. They are used extensively for plating steel objects of irregular shape but are not generally suited to such basis metals as malleable and gray iron. A plain bath produces dull deposits; organic additives can be used to form mirror-bright coatings; and the addition of small amounts of mercury produces a white matte finish. The appearance of the deposit improves with increasing purification of the bath.

Typical operating conditions are: temperature, 104-122 F (plain) or 82-100 F (bright); current density, 9.3-19 amp per sq ft (plain) or 10-50 amp per sq ft (bright).

Cadmium Plating Baths

Commercial cadmium plating is performed almost exclusively in cyanide baths. The solutions are prepared by dissolving cadmium oxide in sodium cyanide solution. The plating solution is operated at room temperature and with current density ranging from 5 to 50 amp per sq ft.

Organic brightening agents, such as complex nitrogen-containing condensation products, piperonal with aluminum, certain sulfonic acids and proprietary compounds, are commonly added. Under certain conditions small amounts of metallic salts such as nickel and cobalt may be used in addition to the organic additive to insure smooth, bright deposits.

The cadmium cyanide bath maintains a low metal ion concentration and consequently has high throwing power. Coatings on parts of irregular shape have a good degree of uniformity.

Thickness of Deposits

Zinc. Commonly specified deposits are 0.0010 in. or more for intermediate conditions, and 0.00015 in. for mild exposures. Thinner coatings can be specified where they are to be given supplementary treatments as described below.

Cadmium. Commonly specified deposits are 0.00050 in. for relatively severe exposures, 0.00030 in. for intermediate conditions and 0.00015 in. for mild exposures. Other thicknesses are specified to meet unusual service conditions.

Treatments for Basis Metals

Zinc plating. Surface preparation of the basis steel is particularly important when plating in acid baths which do not have the detergent properties of the alkaline bath. Organic surface films are removed by agitation in an alkaline cleaner at 195 F. Anodic or cathodic electrolytic cleaning is frequently used. Pretreatment for cyanide plating is usually completed with a room temperature dip in dilute sodium cyanide to remove any oxides formed during previous transfers.

Treatment after plating is generally necessary only with acid-bright coatings because of their tendency to form bulky white corrosion products; these plates can be protected with a clear lacquer or a chromate dip. However, zinc coatings are often given supplementary treatments such as chromating or phosphating, together with a suitable paint system, not only for protection but also to simulate chromium plate. Examples of such parts are refrigerator racks and fan guards.

Cadmium plating. Pretreatment for basis steels is similar to that for zinc cyanide baths. Use of bright **dips after plating to enhance appearance** and resist**ance to corrosion and fingerprinting** has become widespread for cadmium as well as zinc coatings. The procedure is usually to dip for a few seconds in a nitric acid. chromic acid or hydrogen peroxide solution.

Sprayed Metal Coatings

Type →	Aluminum	Babbitt A[a]	Brass (65:35)	Bronze AA[b]	Commercial Bronze	Manganese Bronze	Phosphor Bronze
Specific Gravity	2.41	6.67	7.45	7.06	7.57	7.26	7.68
Ult Ten Str, 1000 psi	19.5	—	12	29	11.5	12	18
Strain at Ult Str, %	0.23	—	0.45	0.46	0.42	0.46	0.35
Rockwell Hardness	H72	H58	B22	B78	B18	B27	B20
Shrinkage, in./in.	0.0068	—	0.009	0.0055	0.011	0.009	0.010
Spraying Speed, lb/hr	18	95	32	24	24	36	31
Spraying Efficiency, %[c]	89	69	81	77	82	79	85
Major Characteristics and Uses[d]	Good corrosion and heat resistance	Good bearing properties	Sprays fast. Fair machine finish	Hard, very wear resistant. Easily machined	Softest bronze. Fair machine finish	Excellent machine finish. Special uses only	Fair machine finish. Special uses only

[a]Lead-free, high tin alloy. [b]Aluminum-iron-bronze. [c]Percent of metal deposited.
[d]All metals have about the same shiny surface after spraying, but surfaces of the various metals differ after machining.

Type →	Tobin Bronze	Copper	Lead	Molybdenum	Monel	Nickel	18-8 Stainless
Specific Gravity	7.46	7.54	10.21	8.86	7.67	7.55	6.93
Ult Ten Str, psi	13	—	—	7.5	21	17.5	30
Strain at Ult Str, %	0.51	—	—	0.30	0.26	0.30	0.27
Rockwell Hardness	B27	B32	—	C38	B39	B49	B78
Shrinkage, in./in.	0.0104	—	—	0.003	0.009	0.008	0.012
Spraying Speed, lb/hr	36	29	80	8	17	18	21
Spraying Efficiency, %[c]	80	80	65	87	85	79	81
Major Characteristics and Uses[d]	General purpose. Fair machine finish	Electrical uses; brazing	Good corrosion resistance. X-ray shielding	Used as bonding coat. Excellent bearing properties	Good corrosion resistance. Good machine finish	Good corrosion resistance. Fair machine finish	High corrosion resistance. Good wearing properties

Type →	High Cr Stainless	Steel (LS)[e]	Steel (0.10% C)	Steel (0.25% C)	Steel (0.80% C)	Tin	Zinc
Specific Gravity	6.74	6.78	6.67	6.78	6.36	6.43	6.36
Ult Ten Str, psi	40	33.5	30	34.7	27.5	—	13
Strain at Ult Str, %	0.50	0.45	0.30	0.46	0.42	—	1.43
Rockwell Hardness	C29	C25	B89	B90	C36	—	H46
Shrinkage, in./in.	0.0018	0.002	0.008	0.006	0.0014	—	0.010
Spraying Speed, lb/hr	19	18	19	19	19	95	61
Spraying Efficiency, %[c]	81	87	87	87	87	73	66
Major Characteristics and Uses[d]	High hardness and wear resistance. Grind finish	Good mechanical and finishing properties	Simple bearing surfaces and press fits. Excellent machine finish	Harder and lower shrinkage than 0.10C. Excellent machine finish	Very hard and wear resistant. Good bearing properties. Grind finish	Good corrosion resistance, especially with foods	Good all-around corrosion resistance

[e]Low shrinkage.

Mechanical Finishes for Aluminum, Copper and Stainless Steel[a]

Type	Appearance	How Finish Is Obtained[b,c]	Uses
Smooth Bright (buffed)	Brightest mechanical finish. Surface is smooth and lustrous, can be made mirror-bright by using fine abrasive electro-brightening in final polishing, or (on aluminum), by electro-brightening or chemical bright-ening. Copper must be plated or clear-lacquered to preserve appearance	Two or three buffing operations (with progressively softer buffs and/or finer compound) following polishing or other finishing operations. Skilled operator needed to prevent buff-burned or pitted surfaces. Approx buffing wheel speeds: stainless 10,000; Al 8000; Cu 6–10,000 sfpm. Aluminum usually given light caustic etch between buffing steps to remove embedded particles	For attractive appearance or high reflectivity. Usually economically feasible only for larger items or close tolerance parts. Examples: household appliances, sanitary equipment, auto and boat trim, light reflectors, jewelry, small objet d'art. Also for Al before anodizing
Smooth Bright (burnished)	Not as bright as buffed surface esp if surface has retained oxide coating or has not been machined. Brightness dependent on time of treatment and relative movement and pressure of burnishing media	Relatively gentle tumbling in barrel with stainless steel balls 1/16–1/2 in. in dia and neutral soap solution (+ soap bark for Cu).[d] Time required: stainless, 1–4; Al, 1½–2½; Cu, 6–48 hr. Hard to get uniform finish on complex-shaped parts	Similar to above, but generally smaller, mass-produced parts or parts difficult to buff. Examples: pen points, eyelets, grommets, auto trunk locks, auto pushbuttons
Satin Semi-Bright (wheel or belt polished)	Smoothest sheen of the satin finishes because of the finer, more irregular scratches. Brightness dependent on fineness of abrasive in final operation	Several polishing operations following grinding.[e] Wheels may be fabric, felt or leather; Tampico brush wheels may also be used, producing slightly duller surface. Lubrication usually required in wheel polishing with finer abrasives; belts reduce danger of overheating. Approx speeds: stainless 4500–7500, Al 5–6000, Cu 6–9000 sfpm. Abrasive usually alumina or silicon carbide (neither emery nor silicon carbide recommended for stainless). Preliminary polishing of Cu often done by sand-bobbing (using abrasive and wheel wet with mineral oil)	For parts where attractive, low reflection finish is desired. Examples: dairy, bar and cafeteria equipment; utensils; auto and furniture handles, knobs, rosettes. Also to prepare for finer finishes
Satin Semi-Bright (wire brushed)	Smooth sheen; smoothness dependent on wire size. Usually brighter than satin finish produced by polishing	Wire brushing of low polished surface entirely free of grease or oil. Brushes for Cu: brass, nickel silver or steel. Brushes for Al: stainless steel, brass, nickel or german silver (stainless preferred to avoid corrosion resulting from embedded particles). Brushes usually 10 in. in dia; wires range from 0.015 in. down to 0.002 in. for smoothest finish. Low pressures used. Wheel speeds range from 2000 rpm for polished sheet to 600 rpm for castings (castings are usually dustblasted or medium sandblasted before brushing). Nitric acid dip may be used after brushing to dissolve embedded particles	Same as above. Widely used on Al, sometimes on Cu. Not used on stainless because of its hard surface
Textured Semi-Bright (hammered)	Decorative finish somewhat similar to wrought silver. Minor scratches and defects obscured	Hammering by hand—the simplest mechanical finish. Parts may be heated in smoky fire and hammered until soot is embedded; polishing of high spots then produces special decorative effect	Used on Al and Cu. Examples: architectural and commercial products, giftware, novelty items
Textured Semi-Bright or Matte (embossed or engraved)	Patterned finish having wide variety of decorative effects	Sheet is passed between embossing rolls or pantograph-engraved; recesses may be filled with enamel for contrast and decoration. Applied to polished, buffed, satin finished, sandblasted (Al) or vapor honed (stainless) surfaces	Decoration and increase in rigidity. Limited to flat work. Examples: building panels, doors, nonskid surfaces, auto trim, plaques, tablets, nameplates
Textured Matte (sandblasted)	Special decorative effects esp by combination with other processes. Surface texture depends on size and type of abrasive, amount of air pressure, and movement and angle of nozzle. Surface collects dirt unless protected, as by clear lacquer	Spraying surface with fine abrasive or slurry by air pressure. Careful control of nozzle is needed for desired effects and to prevent distortion. Contrasting surfaces obtained by enameling, anodizing, blackening, highspot polishing, caustic etching, etc.	Primarily for aluminum.[f] Examples similar to above; not limited to flat pieces

[a] Including aluminum and copper alloys.
[b] Stainless steel can be purchased with a number of different mill finishes. The bright cold rolled finish is usually specified for subsequent polishing or buffing. If severe forming is to be done, dull cold rolled may be preferable. Higher mill finishes available include polished, Tampico brush-finished and semi-mirror-finished.
[c] Aluminum mill finishes include a variety of embossed designs and a fluted finish.
[d] Another tumbling process—with granite chips, alumina or silica sand—is used to deburr and smooth stainless and aluminum parts, but does not produce as bright a surface and is not recommended for close tolerance parts.
[e] On aluminum, a somewhat brighter surface can be obtained by further finishing with steel wool and kerosene; a somewhat duller surface by low or coarse polishing followed by rubbing with steel wool and soapy water.
[f] Special effects on copper often achieved by engine turning. Stainless is usually vapor honed.

Organic Coatings[a]

Type →	Alkyd	Alkyd-Amine	Alkyd-Urea	Styrenated Alkyd	Alkyd-Phenolic	Alkyd-Silicone	Phenolic
CHEMICAL RESISTANCE							
Exterior Durability	E	E	E	E	E	E	E
Salt Spray	E	VG	G	G	E	E	E
Solvents—Alcohols	F	G	G	G	G	F	E
Solvents—Gasoline	G	E	E	E	E	E	E
Solvents—Hydrocarbons	G	E	E	E	E	P	E
Solvents—Esters, Ketones	P	P	P	P	F	P	E
Solvents—Chlorinated	P	P	P	P	F	P	G
Beverages, Foods	F	G	G	VG	VG	P	E
Salts	VG	E	E	E	E	F	E
Ammonia	P	P	P	P	P	P	P
Alkalis[b]	G, G	VG, G	G, G	G, VG	F, P	P, P	P, P
Acids—Mineral[c]	F, P, P	G, F, P	F, P, P	G, F, P	VG, G, F	G, P, P	E, E, E
Acids—Oxidizing[c]	P, P, P	F, P, P	F, P, P	F, P, P	G, F, P	P, P, P	E, E, VG
Acids—Organic (acetic, formic, etc.)[c]	P, P, P	P, P, P	P, P, P	P, P, P	F, P, P	P, P, P	G, F, P
Acids—Organic (oleic, stearic, etc.)	F	G	F	F	VG	G	E
Acid—Phosphoric	P	P	P	P	P	P	F
Water (salt, fresh)	F	G	F	G	E	E	E
PHYSICAL PROPERTIES							
Sward Rocker Hard. (8th day)	24	30	28	28	34	16	38
Flexibility	E	VG	VG	G	G	F	G
Abrasion Res, cycles[d]	3500	>5000	>5000	>5000	>5000	1000	>5000
Max Rec Svc Temp, F	200	250	225	200	250	1000	350
Toxicity	None	Slight	Slight	Slight	None	Slight	None
Impact Res	VG	E	E	G	G	G	G
Heat Res[e]	G	VG	VG	G	G	VG	G
Dielec Properties	G	G	G	G	VG	E	E
Adhesion to—							
Wood, Masonry	E	E	E	E	E	E	G
Ferrous Metals	E	E	E	E	E	G	E
Nonferrous Metals	F	E	VG	E	E	F	E
Old Paints	VG	G	G	VG	G	E	G
DECORATIVE PROPERTIES							
Choice of Colors[f]	U	U	U	U	SL	U	L
Color Retention[g]	G	VG	VG	G	P	E	P
Initial Gloss	E	E	E	E	VG	E	VG
Gloss Retention	E	G	F	G	F	E	F
APPLICATION							
Ease of Application	E	Bake req	Bake req	E	E	E	E
Metal Surface Prep	Primer	No primer	No primer	No primer	No primer	Primer	No primer
Solvent for Application[h]	Hyd	Hyd	Hyd	Hyd	Hyd	Hyd	Alc
Methods[f]	U	U	U	U	U	U	U
Cure[i]	A or B	B	B	A or B	A or B	A or B	A or B
Bake Drying Time[j]	30 min (275 F)	20 min (320 F)	20 min (320 F)	15 min (300 F)	30 min (350 F)	30 min (350 F)	30 min (350 F)
Air Drying Times							
Touch	2 hr	—	—	10 min	20 min	45 min	10 min
Handle	4 hr	—	—	30 min	60 min	2 hr	30 min
Re-Coat	4 hr	—	—	4 hr	6 hr	4–6 hr	30 min
Hard	12 hr	—	—	4 hr	6 hr	12 hr	4 hr
Corr Res	48 hr	—	—	48 hr	48 hr	12 hr	24 hr
Coverage, sq ft/gal/mil	450	450	450	400	450	500	350
Coat Thk (avg), mil	1.5	1.5	1.5	1.5	1.5	0.6	1.5

[a] E = excellent; VG = very good; G = good; F = fair; P = poor. Ratings are relative only to organic coatings.
[b] Two ratings are for dilute (< 20%) and conc, resp. [c] Three ratings are for dilute (< 10%), medium (10–30%) and conc, resp.
[d] Taber CS–10 wheel. [e] In general, E = 700–1000 F; VG = 350–700 F; G = 200–350 F; P = < 200 F.
[f] L = limited (pure white cannot be formulated); SL = slightly limited (difficulty in formulating whites and pastels); U = unlimited (any color can be formulated).
[g] Based on white coatings with titanium dioxide pigment. [h] Hyd = hydrocarbons; alc = alcohols.
[i] A = can be air dried; B = can be baked. In general, any coating that can be air dried or baked will perform better if baked.
[j] Full corrosion resistance is obtained immediately upon cooling.

continued

Organic Coatings—continued[a]

Type →	Silicone	Epoxy (100%)	Epoxy-Amine	Epoxy-Urea	Epoxy-Melamine	Epoxy-Phenolic	Epoxy-Ester
CHEMICAL RESISTANCE							
Exterior Durability	E	E	E	E	E	E	E
Salt Spray	E	E	VG	VG	VG	VG	E
Solvents—Alcohols	P	E	E	E	E	E	VG
Solvents—Gasoline	VG	E	E	E	E	E	E
Solvents—Hydrocarbons	VG	E	E	E	E	E	VG
Solvents—Esters, Ketones	P	F	VG	VG	VG	E	F
Solvents—Chlorinated	P	E	E	E	E	E	F
Beverages, Foods	P	E	E	E	E	E	VG
Salts	G	E	E	E	E	E	E
Ammonia	P	P	P	P	P	VG	P
Alkalis[b]	P, P	E, E	E, E	E, E	E, E	E, E	E, E
Acids—Mineral[c]	G, P, P	E, VG, G	E, VG, G	E, VG, F	E, VG, G	E, E, E	G, F, P
Acids—Oxidizing[c]	P, P, P	G, P, P	G, P, P	F, P, P	G, P, P	E, VG, P	F, P, P
Acids—Organic (acetic, formic, etc.)[c]	P, P, P	G, F, P	G, F, P	F, P, P	G, F, P	E, E, VG	F, P, P
Acids—Organic (oleic, stearic, etc.)	P	E	E	E	E	E	E
Acid—Phosphoric	P	P	P	P	P	E	P
Water (salt, fresh)	E	VG	G	G	G	E	VG
PHYSICAL PROPERTIES							
Sward Rocker Hard. (8th day)	16	36	36	34	36	44	30
Flexibility	F	E	G	VG	VG	VG, E	G
Abrasion Res, cycles[d]	2500	>5000	>5000	>5000	>5000	>5000	>5000
Max Rec Svc Temp, F	1200	400	400	400	400	400	300
Toxicity	Slight	Slight	Slight	Slight	Slight	Slight	Slight
Impact Res	G	G	G	G	G	G	E
Heat Res[e]	E	VG	VG	VG	VG	VG	G
Dielec Properties	E	VG	VG	VG	VG	VG	VG
Adhesion to—							
Wood, Masonry	E	VG	VG	VG	VG	VG	E
Ferrous Metals	G	E	E	E	E	E	E
Nonferrous Metals	F	E	E	E	E	E	VG
Old Paints	E	P	P	P	P	P	F
DECORATIVE PROPERTIES							
Choice of Colors[f]	U	SL	SL	SL	SL	L	SL
Color Retention[g]	G	G	G	G	G	P	E
Initial Gloss	E	VG	VG	VG	VG	VG	E
Gloss Retention	E	F	F	F	F	F	G
APPLICATION							
Ease of Application	E	Catalyst req	Catalyst req	Bake req	Bake req	Bake req	E
Metal Surface Prep	Primer	No primer	No primer	No primer	No primer	No primer	Primer
Solvent for Application[h]	Hyd	Ketone	Blend	Blend	Blend	Blend	Hyd
Methods[f]	U	L	L	L	L	L	U
Cure[i]	A or B	A	A	B	B	B	A or B
Bake Drying Time[j]	1 hr (400 F)	—	—	30 min (350 F)	30 min (350 F)	30 min (400 F)	30 min (320 F)
Air Drying Times							
Touch	45 min	45 min	45 min	—	—	—	1 hr
Handle	2 hr	2 hr	2 hr	—	—	—	2 hr
Re-Coat	4–6 hr	6–8 hr	6–8 hr	—	—	—	8 hr
Hard	12 hr	12 hr	12 hr	—	—	—	8 hr
Corr Res	12 hr	7–10 days	7–10 days	—	—	—	5 days
Coverage, sq ft/gal/mil	350	450	500	500	500	450	450
Coat Thk (avg), mil	1.0	1.8	1.8	1.8	1.8	1.8	1.5

Notes: See opposite page.

Organic Coatings—concluded[a]

Type →	Vinyl	Vinyl-Alkyd (approx 1:1)	Chlorinated Rubber	Fluorocarbon (air dried)	Acrylic	Nitro-cellulose	Butyrate
CHEMICAL RESISTANCE							
Exterior Durability	E	E	E	E	E	E	E
Salt Spray	E	E	E	E	E	E	E
Solvents—Alcohol	E	G	F	F	G	G	G
Solvents—Gasoline	E	E	G	F	G	G	G
Solvents—Hydrocarbons	G	P	P	P	F	F	F
Solvents—Esters, Ketones	P	P	P	P	P	P	P
Solvents—Chlorinated	P	P	P	P	P	P	P
Beverages, Foods	E	F	G	E	VG	P	G
Salts	E	G	E	E	VG	G	VG
Ammonia	E	P	VG	E	P	P	P
Alkalis[b]	E, E	G, P	VG, F	E, E	G, F	P, P	P, P
Acids—Mineral[c]	E, E, G	VG, G, P	E, G, P	E, E, E	G, F, P	G, F, P	G, F, P
Acids—Oxidizing[c]	E, VG, G	P, P, P	E, E, P	E, E, E	F, P, P	P, P, P	P, P, P
Acids—Organic (acetic, formic, etc.)[c]	E, P, P	G, F, P	G, P, P	E, E, E	P, P, P	P, P, P	P, P, P
Acids—Organic (oleic, stearic, etc.)	E	E	E	E	F	F	F
Acid—Phosphoric	E	F	G	E	P	P	P
Water (salt, fresh)	E	E	VG	E	E	F	E
PHYSICAL PROPERTIES							
Sward Rocker Hard. (8th day)	20	26	24	20	24	26	26
Flexibility	E	VG	VG	G	E	E	E
Abrasion Res, cycles[d]	>5000	2500	>5000	1000	2500	2500	2500
Max Rec Svc Temp, F	180	200	250	212	180	180	180
Toxicity	None	None	Slight	Slight	None	None	None
Impact Res	E	VG	G	E	E	E	E
Heat Res[e]	P	F	P	E	P	P	P
Dielec Properties	E	G	E	E	VG	P	G
Adhesion to—							
Wood, Masonry	E	E	E	E	E	E	E
Ferrous Metals	VG	VG	F	VG	VG	VG	VG
Nonferrous Metals	VG	VG	VG	VG	VG	G	G
Old Paints	G	G	E	P	P	P	P
DECORATIVE PROPERTIES							
Choice of Colors[f]	U	U	L	U	U	U	U
Color Retention[g]	VG	G	G	G	E	E	E
Initial Gloss	G	E	F	E	E	E	E
Gloss Retention	F	F	F	F	E	VG	E
APPLICATION							
Ease of Application	VG	E	E	VG	VG	VG	VG
Metal Surface Prep	Primer	Primer	Primer	Primer	Primer	Primer	Primer
Solvent for Application[h]	Blend	Ketone	Hyd	Blend	Blend	Blend	Blend
Methods[f]	L	L	U	L	U	U	U
Cure[i]	A or B	A	A or B	A or B	A	A	A
Bake Drying Time[j]	15 min (300 F)	—	15 min (300 F)	15 min (300 F)	—	—	—
Air Drying Times							
Touch	15 min	15 min	45 min	5 min	5 min	5 min	5 min
Handle	30 min	2 hr	2 hr	15 min	15 min	15 min	15 min
Re-Coat	4–6 hr	4–6 hr	4–6 hr	12 hr	15 min	15 min	15 min
Hard	4–6 hr	6–8 hr	4–6 hr	12 hr	12 hr	12 hr	12 hr
Corr Res	24 hr	6 hr	24 hr	12 hr	24 hr	24 hr	24 hr
Coverage, sq ft/gal/mil	250	300	450	200	350	200	200
Coat Thk (avg), mil	1.0	1.2	1.5	1.0	1.0	1.0	1.0

[a] E = excellent, VG = very good, G = good, F = fair, P = poor. Ratings are relative only to organic coatings.
[b] Two ratings are for dilute (< 20%) and conc, resp. [c] Three ratings are for dilute (< 10%), medium (10–30%) and conc, resp.
[d] Taber CS–10 wheel. [e] In general, E = 700–1000 F, VG = 350–700 F, G = 200–350 F, P = < 200 F.
[f] L = limited (pure white cannot be formulated); SL = slightly limited (difficulty in formulating whites and pastels); U = unlimited (any color can be formulated).
[g] Based on white coatings with titanium dioxide pigment. [h] Hyd = hydrocarbons; alc = alcohols.
[i] A = can be air dried; B = can be baked. In general, any coating that can be air dried or baked will perform better if baked.
[j] Full corrosion resistance is obtained immediately upon cooling.

Porcelain Enamels

Composition

Porcelain enamel coatings are formulated for specific applications. They consist essentially of oxide color pigments, opacifiers and gases colloidally dispersed in fused silicates. They are smooth, hard and lustrous, and resist temperatures as high as 1000 F (except on aluminum). They may be formulated to provide an attractive, easily cleaned, durable finish; a chemical resistant barrier; or a wear resistant surface.

The enamels generally comprise one, two or three layers. The first layer on ferrous metals is usually a 3 to 4-mil "ground coat" (analogous to an organic primer) containing an oxide of cobalt, nickel or molybdenum that promotes good adhesion with the base metal. Where appearance is not important a ground coat may be used alone; but ordinarily it is followed by one or two 3 to 4-mil top coats, depending on the thickness required to achieve the desired opacity or protection.

Two general types of porcelain enamel frits are most widely used. Titanium types—so called because titanium dioxide is the opacifier—are preferred for white coatings because of their high covering power which makes necessary only a single 3 to 4-mil top coat. These relatively thin coatings (about 7 mils with a ground coat) have good acid resistance; good abrasion resistance; and good resistance to chipping during shearing, bending, punching and other fabricating operations. Titanium coatings can also be used for light or pastel colors, but where deep, bright colors are desired, acid resistant antimony type coatings are used. These coatings do not have the covering power of titanium types and require two 3 to 4-mil top coats for good appearance. They are also less abrasion resistant than titanium types.

Frits for aluminum and aluminized steel contain lead and are softer than conventional enamels. Lead-free frits are undergoing field tests.

Base Metals

Enameling iron. Ingot iron specially made for enameling. Produced in several grades suitable for various degrees of drawing or spinning. Good resistance to sagging and warping during firing. Produces minimum of surface defects in enamel.

Mild steel. Open hearth rimmed steel sheets such as AISI 1008 and 1010. Available in drawing quality grade. Likely to produce surface defects in enamel. Poor resistance to sagging and warping during firing.

Titanium enameling steel. Basic open hearth steel containing enough titanium to combine with and stabilize the carbon. Better drawing quality than enameling iron but somewhat inferior to the best deep drawn grades of mild steel. Yield strength comparable to that of enameling iron. Excellent sag resistance. Can be coated directly with white covercoat enamels, making possible thin coatings. Expensive and somewhat limited in supply.

Cast iron. Typical satisfactory composition: 2.50 silicon, 0.70 phosphorus, 0.60 manganese, 0.08 sulfur, 3.00 free carbon and 0.40% combined carbon. Must have reasonably dense and uniform structure and be free from porosity, slag inclusions and segregation. Should be capable of developing a fairly smooth surface when sandblasted.

Aluminum. Includes wrought 1100, 3003, 6053 and 6061, and cast 43. Used for light weight, workability and resistance to edge corrosion. Can be cut without spalling after enameling. Requires prior surface treatment.

Aluminized steel. Combines strength, rigidity and sag resistance of steel with much of the workability and corrosion resistance of enameled aluminum. Requires no prior surface treatment.

Stainless steel. Not commercially important at present, but promising because of its corrosion resistance and the fact that, unlike aluminum, stainless enameled on only one side does not require straightening after firing.

Appearance

Color. Strongest, brightest colors are obtained in clear glasses, and some desirable colors such as the cadmium-selenium reds and oranges and the cadmium yellows can be obtained only in clear glasses. Moderately strong to bright colors can be obtained with semi-opaque antimony and zirconium frits.

Light to moderately strong colors are obtained with reduced opacity or "semi-opaque" titanium frits. Most stable colors are ivory-yellow, yellow, yellow-brown and blue-green; however, pink, gray and other popular decorator colors are currently in production even though some, notably pink, require very expensive raw materials. Semi-opaque enamels are applied about 20% thicker than standard white enamels. Weak or light pastel colors can be obtained with opaque titanium frits. Crimson to purple range of colors is still virtually impossible to obtain satisfactorily.

Metallic finishes such as copper, bronze, gold and gunmetal can be produced by some enamelers. Speckled finishes, once limited to white on dark blue or black, are now available in a greater variety of colors and designs. A wide range of luminescent colors that glow in ultraviolet light can be produced.

Precolored frits, once available only in intense blues and blacks, are now available in blue-green and in several lighter colors.

Pattern. Available in wood grain and marble-like patterns, in speckled designs, and in various other novelty patterns.

Texture. Ranges from extremely high gloss to a dull, full matte. Both glossy and matte finishes can be obtained in colors.

Opacity. Varies with color. White enamels usually require reflectance of 70 to 80% for satisfactory hiding power.

Thickness

The conventional porcelain enamel coating on steel consists of a ground coat and a cover coat having a total thickness of 7-8 mils. Enamel coatings on heavy castings are sometimes much thicker (up to 25 mils). Thinner coatings can be achieved by using special enamels, special base metals, or special surface treatments prior to enameling. For example, single coats of 3-4 mils are used on aluminum and aluminized steel. Titanium-bearing steel requires only a single coat. Some of the low firing enamels (i.e., enamels fired at temperatures as low as 1250 F) can be applied in a single coat. Promising surface treatments include application of a phosphate coating, and etching or blasting followed by electroless nickel plating.

Application Methods

Porcelain enamel coatings are applied by hand spraying, hand dipping, automatic spraying, automatic dipping and flow coating.

Automatic spraying provides more uniform coatings than hand spraying, reducing the amount of enamel needed to insure a specified minimum thickness. Electrostatic spraying reduces overspraying, producing potentially significant materials savings, particularly where expensive colored enamels are used.

Mechanized dipping, relatively new, is more adaptable to complex parts than automatic spraying. Flow coating is particularly advantageous for large cylindrical parts. Flow coated enamels are thinner at the top of the part and are prone to drain streaks.

Firing temperatures of ground coats range from 1600 to 1700 F. Firing temperatures of conventional cover coats on steel range from 1350 to 1500 F. Some of the new low firing enamels mature at temperatures as low as 1250 F. Enamels for aluminum are fired at about 1000 F.

Chemical Resistance

Acid resistance at room temperature. Enamels are rated AA, A, B, C or D, depending on their performance in the standard PEI T-7 or ASTM C 282 test. An enamel surface is exposed to a 10% solution of citric acid for 15 min at 80 F. The enamel is rated according to the appearance of the attacked area and the extent to which it retains a soil. Enamels with an acid resistance rating of A or above are usually specified where acid resistance is required.

Boiling acid resistance. Measured as weight loss of specimen exposed to boiling 6% solution of citric acid for 2½ hr (ASTM C 283).

Weathering resistance. Porcelain enamels that have acid resistance of at least Class B are usually able to withstand weathering for many years without becoming objectionably faded or etched. Enamels of less than Class B acid resistance usually exhibit poor weathering resistance. Certain AA acid resistance enamels containing a cadmium-selenium pigment appear to have poor weathering resistance.

Alkali resistance. Enamels with good alkali resistance are available. No standard test exists, but a test widely used consists of measuring the loss in weight and gloss after exposure to a hot sodium pyrophosphate solution.

Physical and Mechanical Properties

Abrasion resistance. Porcelain enamels combine a Mohs hardness of 4 to 6 with an exceptionally smooth surface, resulting in good resistance to scratching and abrasion. Abrasion resistance of a porcelain enamel is determined by abrading a specimen for a given time with an abrasive charge of grit, steel balls and water.

Surface abrasion resistance is an index of enamel's ability to retain its appearance after being subjected to abrasion at or near the surface. Index is percentage of original gloss retained after specimen has been abraded for about 5 min (PEI T-2).

Subsurface abrasion resistance is index of enamel's ability to protect underlying metal from exposure. Index consists of rate of weight loss over three successive 15-min abrasion periods (PEI T-2).

Torsion resistance. Torsion resistance is better in softer enamels and thinner coatings. It is determined by twisting enameled metal angle until enamel fails along apex. Angle of twist at which failure occurs is index of resistance to torsion (PEI T-5).

Adherence. Ability of enamel to protect base metal after it has been exposed to deformation is measured by adherence index. Index is determined by deforming an enameled metal specimen, then measuring relative areas of exposed metal and adhering enamel (PEI T-17, ASTM C 313).

Thermal shock resistance. Porcelain enamels do not normally fail from thermal shock unless they are cooled very rapidly from a high temperature. Coatings quenched with water may crack or spall. Thin coatings stand up much better than thick coatings. A standard test is under consideration by PEI, and a standard test for enameled kitchenware has been adopted by ASTM.

Thermal expansion. Thermal coefficient of expansion of an enamel should be such that from the firing temperature to the temperature of solidification no undue strains are set up between coating and base metal. In general, coefficient of expansion of enamels for flatware should be slightly greater than that of the base metal, and coefficient of enamels for cast iron should be close to that of the casting.

Heat resistance. Most enamels soften at about their firing temperature, but limiting service temperature is considerably lower and ranges from about 600 to 1000 F, depending on the application. In some cases service temperatures are limited by local strains set up as a result of differences in thermal expansion.

Clad and Precoated Metals

Surface ↓	Base Metal		Coating or Cladding		Critical Functions, Properties	Typical Applications
	Metal	Form	How Applied	Thickness, Finish		
Aluminum and Its Alloys						
Aluminum	Steel, low carbon or copper-bearing	Sheet, strip, 0.016–0.112 in.	Hot dipped	0.001 in. on each side (0.50 oz/sq ft)	High heat reflectivity. High temperature oxidation resistance. Forms refractory iron-aluminum alloy at 1000 F. Strong, low cost base	Oven door liners, aircraft fire walls, auto mufflers, broiler parts, baffles for space heaters, toaster inner parts, water heater casings, jet engine parts
Aluminum	Steel (ASTM A 122)	Strand, 7-wire, ⅛–⅝ in.	Hot dipped	0.40–1.00 oz/sq ft (Class A)	Atmosphere resistance. Galvanic protection. Strong base. Longer life than zinc coated steel	Guy wires, span wires, overhead ground wires
Aluminum [a]	Steel, low carbon	Strip, 0.005 in., annealed	Clad by pressing, rolling	10% of thickness on each side	High temperature oxidation resistance. At 1000 F forms gray iron-aluminum alloy that gives 85% black body radiation. Cheaper than carbonized nickel or nickel-clad steel. Conserves nickel	Anode plates for electronic receiving tubes
Aluminum [b]	Steel, low carbon	Same as above	Clad by pressing, rolling	Same as above	Same as above, but suitable for higher ambient temperatures	Anode plates for electronic receiving tubes where close tube spacing makes external temperature too high for aluminum
1100	Aluminum (2024)	Sheet, 0.016–0.250 in., O or T3	Clad by direct rolling or casting, rolling	2–15% of thickness	Atmosphere resistance. Galvanic protection. Strong base	Military and commercial aircraft frames, cooking utensils, hardware
6053	Aluminum (2014)	Sheet, 0.015–0.250 in., O, T4 or T6	Clad by direct rolling or casting, rolling	Same as above	Atmosphere resistance. Galvanic protection. Wear resistance. Workable base	Power shovel bails, aircraft fittings, heavy duty forgings
6053	Aluminum (5056)	Wire, up to ⅜ in. dia	Clad by casting, drawing	Same as above	Same as above	Insect screening
7072	Aluminum (3003 or 3004)	Sheet, 0.015–0.250 in., temper rolled	Clad by direct rolling or casting, rolling	Same as above	Atmosphere resistance. Galvanic protection. Workable, weldable base	Cooking utensils, gasoline and oil tanks, bus and train trim
7072	Aluminum (3003)	Tube, ⅛–11 in. o. d.	Clad by swaging, drawing	2–15% of thickness on inside	Same as above	Heat exchangers for process industries
7072	Aluminum (7075)	Sheet, 0.020–0.188 in., O or T6	Clad by direct rolling or casting, rolling	2–15% of thickness	Atmosphere resistance. Galvanic protection. High strength base	Aircraft structural parts
Copper and Its Alloys						
Brass, Copper	Steel, low carbon	Sheet, strip, 0.008–0.250 in., temper rolled	Electroplated	0.10–0.15 mils on one or both sides. Natural satin or bright. May be striped, crimped, corrugated	Decoration. Atmosphere resistance. Good solderability	Luggage, hardware, costume jewelry, flashlight cases, lamp tubing, chime tubes, cymbals, picture frames, display stands
Brass [c]	Steel, low carbon	Strip, 0.004–0.125 in., temper rolled	Clad by direct rolling	10 or 15% of thickness on one or both sides	Same as above	Cosmetic cases, bed frames, nameplates, gaskets

[a] 1½% silicon. [b] 1½% silicon with 330 nickel on other side. [c] 70–30 or 85–15.

Clad and Precoated Metals—continued

Surface ↓	Base Metal		Coating or Cladding		Critical Functions, Properties	Typical Applications
	Metal	Form	How Applied	Thickness. Finish		
Copper and Its Alloys (continued)						
Brass [d]	Steel, low carbon	Wire, 0.090–0.375 in.	Clad by plating, drawing	½–1 mil (brass only flash)	Decoration. Atmosphere resistance. Cheap, strong base metal. Conserves brass	Curtain rods, indoor television antennas, lamp stands
Brass, Copper	Zinc	Sheet, strip 0.006–0.125 in.	Electroplated	0.10–0.15 mils on one or both sides. Natural, satin or bright. May be striped, crimped, corrugated	Decoration	Moldings, ornaments, trim, badges, buttons
Bronze [e]	Steel, low carbon	Strip, 0.004–0.125 in., temper rolled	Clad by direct rolling	10 or 15% of thickness on one or both sides	Decoration. Atmosphere resistance. Cheap, strong base metal. Conserves copper	Ornamental trim, shell cases
Copper	Steel, carbon	Wire, 0.006–0.500 in. Also ribbon	Clad by plating, drawing	0.25–35% by weight	Electrical conductivity. Atmosphere resistance. Strong base metal. Conserves copper	Lead-in wires for electronic tubes, communication and power lines, lightning rods, fencing, springs, plumbing float racks
Copper	Aluminum (1100 or 5052)	Sheet, strip, 0.004–0.125 in. Also seamless tubing, wire, bus bars	Clad by pressing, rolling	10% of thickness on each side, or 20% on one side. Also 90/10, 70/30, 5/90/5	Thermal, electrical conductivity. Good solderability. Plating base. Lightweight base metal. Conserves copper	Waveguides, variable condenser blades, pots and pans, downspouts, heat transfer fins, jewelry, shims, bushings, terminals
Copper	Beryllium copper (25)	Strip, 0.010–0.030 in., temper rolled	Clad by direct rolling	10–15% of thickness on one side	Electrical conductivity. Base has good spring properties	Current-carrying springs
Copper	Steel, low carbon	Strip, 0.004–0.125 in., temper rolled	Clad by direct rolling	10 or 15% of thickness on one or both sides	Atmosphere resistance. Compressible surface. Thermal conductivity. Good solderability. Cheap, strong base. Conserves copper	Gaskets, automotive radiator tanks, electrical contact "points" and switches, immersion heater base plates
Copper	Steel, high carbon	Strip, 0.012–0.025 in., annealed	Clad by pressing, rolling	5–20% of thickness on one side, or 10–35% on each side	Electrical conductivity. Plating base. Base has good spring properties	Fuse clips, thin-blade or spiral type springs, pen and pencil clips
Copper	Steel, low alloy (with boron)	Wire, 0.003–0.072 in.	Clad by casting, rolling, drawing	10% of radius for "30% conductivity," 12½% for "40% conductivity"	Electrical conductivity. Atmosphere resistance. Plating base. Strong base metal. Conserves copper	Grid support rods for electronic tubes, communication lines, slide fasteners, plated costume jewelry, lawn mower baskets, fencing, ground rods
Copper	Steel, carbon or low alloy	Plate, ⅛–1¼ in. Also heads	Clad by direct rolling	10–20% of thickness on one side	Resistance to corrosion, erosion. Uniform heat transfer. Conserves copper	Chemical process equipment
Cupro-Nickel [f]	Steel, low carbon	Strip, 0.004–0.125 in., temper rolled	Clad by direct rolling	10 or 15% of thickness on one or both sides	Same as above	Chemical process equipment
Phosphor Bronze (C)	Copper	Strip, 0.012–0.025 in., spring temper	Clad by direct rolling or pressing, rolling	25% of thickness on each side. Also 35/30/35	Good spring properties. Base has high electrical conductivity	Flat spring blades for switches and electrical meters, other current carrying springs

[d] Over copper.

[e] 90–10.

continued

Clad and Precoated Metals—continued

Surface ↓	Base Metal		Coating or Cladding		Critical Functions, Properties	Typical Applications
	Metal	Form	How Applied	Thickness, Finish		
Chromium						
Chromium [f]	Aluminum, brass, copper, zinc	Sheet, strip, 0.005–0.230 in., temper rolled	Electroplated	0.15–0.25 mils on one or both sides. Natural, satin, or bright. May be striped, crimped, corrugated	Decoration	Toys, reflectors, trim, squeegee plates, etched nameplates, display signs, grills and louvers, miniature letters, auto accessories
Chromium [f]	Steel, low carbon	Sheet, strip, 0.004–0.250 in., temper rolled	Electroplated	Same as above	Decoration, atmosphere resistance	Switchplates, heater parts, mirror backs, display stands, ferrotype plates, toaster shells, chime tubes
Gold and Its Alloys						
Gold [g]	Bronze, nickel silver, nickel, sterling silver	Strip, 0.007–0.120 in. Also tubing, wire	Clad by brazing, rolling	More ("gold-filled") or less ("rolled gold plate") than 1/20 by wt on one or both sides	Decoration. Atmosphere resistance. Relatively low cost base	Jewelry, including watchcases, bracelets, rings, lockets, eyeglass frames
Gold [h]	Copper, brass, nickel, monel	Strip, 0.010–0.030 in., temper rolled	Clad by brazing, rolling	0.5 mils or more	Chemical resistance. Relatively low-cost base	Bursting disks, other chemical process equipment
Lead and Its Alloys						
Lead [i]	Steel, low carbon	Sheet, strip, 0.005–0.125 in.	Electroplated	¼, ½ or 1 mil min on each side (ASTM B200). Natural or polished	Atmosphere resistance. Good solderability, drawability. Paint base	Telephone cable sheathing, containers
Lead	Copper (ASTM B 101)	Sheet, strip, 0.019–0.028 in.	Plated (type II) or hot dipped (type I)	0.060–0.075 (A), 0.10–0.15 (B) or 0.20–0.25 (C) lb/sq ft on each side	Atmosphere resistance	Roofing, flashing
Lead [j]	Copper, low carbon steel	Tubing, ¾–2⅛ in. o. d.	Clad by extruding or simultaneous drawing	1/32–½ in. on outside	Chemical resistance. Low cost. Base has good strength, high thermal conductivity	Heat exchanger coils for chemical process equipment
Lead	Steel, low carbon	Plate, sheet, strip, ½–10 in. Also rod, angles, channels	Clad by casting, pressing	⅛–½ in. (chemical) up to 8–10 in. (radiation) on one side	Chemical resistance. High density. Low cost. Strong base metal	Chemical process equipment; equipment for use with x-rays, radium and nuclear processes
Lead [k]	Steel, low carbon	Sheet, strip, 0.005–0.125 in.	Hot dipped	0.35 oz/sq ft on each side. Natural or polished	Atmosphere resistance. Good solderability, drawability. Paint base. Higher corrosion resistance than terne plate	Ammunition boxes, ducts
Terne [l]	Steel, low carbon	Sheet, 0.019–0.063 in.	Hot dipped	0.16–0.80 mil on each side	Atmosphere resistance. Good solderability, drawability. Excellent paint base. Low cost	Gasoline tanks, caskets, paint and oil containers, door frames

[f]Over nickel.
[g]10K or more.
[h]14K or more.
[i]Sometimes over copper
[j]ASTM B29.
[k]90–95%.
[l]75–85% lead.

Clad and Precoated Metals—continued

Surface ↓	Base Metal		Coating or Cladding		Critical Functions, Properties	Typical Applications
	Metal	Form	How Applied	Thickness, Finish		
Nickel and Its Alloys						
Inconel, Monel	Steel, carbon or low alloy	Plate, 3/16 to 1¼ in. (double-clad) or 3½ in. (single-clad). Also heads	Clad by direct rolling	5–25% of thickness on one side, or 5–15% on each side	Resistance to corrosion, erosion. Uniform heat transfer. Low cost base metal. Conserves nickel	Process equipment
Monel	Steel, low carbon	Strip, 0.010–0.030 in. temper rolled	Clad by direct rolling	10–15% of thickness on one or both sides	Same as above	Process and marine equipment
Nickel	Aluminum, brass, copper, zinc	Sheet, strip, 0.005–0.230 in., temper rolled	Electroplated	0.15–0.20 mil on one or both sides. Natural, satin or bright. May be striped, crimped, corrugated	Decoration	Lighting fixtures, nameplates, fryer lids, broiler pan grids, ice bag caps, eraser disks, license plate frames, buttons
Nickel	Copper	Wire, 0.001–0.312 in. Also ribbon	Clad by plating, drawing	0.1–25 mils	High temperature oxidation resistance. Electrical conductivity	Electrical circuits subjected to high temperatures
Nickel [d]	Steel, low carbon	Sheet, strip, 0.001–0.250 in., temper rolled	Electroplated	0.15–0.20 mil on one or both sides. Natural, satin or bright. May be striped, crimped, corrugated	Decoration, atmosphere resistance	Toys, brush ferrules, nameplates, tack beading, paint test panels, broiler trays, fan blades, knives, chocolate molds, flashlights
Nickel	Iron or carbon steel	Wire, 0.006–0.500 in. Also ribbon	Clad by plating, drawing	0.1–25 mils (½–10% by weight)	Atmosphere resistance. High temperature oxidation resistance	Grid support rods, lead-in wires for electronic tubes; typewriter key levers, springs, clothes racks, stapling and stitching wire
A Nickel	Copper	Wire, 0.001–0.500 in. Also ribbon	Clad by swaging, drawing	27–30% by weight	Corrosion resistance. Electrical conductivity	Electrical circuits subjected to corrosive atmospheres
A or L Nickel	Steel, carbon or low alloy	Plate, 3/16 to 1¼ in. (double-clad) or to 4 in. (single-clad). Also heads	Clad by direct rolling	5–30% of thickness on one side or 5–15% on each side	Resistance to corrosion, erosion. Uniform heat transfer. Low cost base metal. Conserves nickel	Process equipment
L Nickel	Brass, low carbon steel	Strip, 0.010–0.030 in., temper rolled	Clad by rolling	10–15% of thickness on one or both sides	Same as above	Process equipment
330 Nickel	Steel, low carbon	Strip, 0.005 in., annealed	Clad by pressing, rolling	10% of thickness on each side. Often carbonized	High temperature oxidation resistance. Black body radiation. Low cost base metal. Conserves nickel	Anode plates for electronic receiving tubes
Platinum and Platinum Group Alloys						
All	Copper, brass, bronze, nickel	Strip, 0.010–0.030 in., temper rolled	Clad by brazing, rolling	1 or more mils on all or part of one or both sides. May be edge-laid, inlaid	Electrical contact properties. High chemical resistance. Low cost base metal	Electrical contacts, slip rings, chemical crucibles
Platinum	Copper, brass, bronze, nickel	Tubing, seamless, up to 1¼ in. o. d. Also wire	Clad by brazing, rolling	0.005–0.007 in.	High chemical resistance. Low cost base metal. Thermal conductivity	Heat exchangers for chemical processes
Platinum	Molybdenum	Wire, 0.003–0.060 in.	Clad by casting, rolling, drawing	Up to 0.001 in. (38% by wt)	High work function (low primary electron emission). Refractory base metal	Grids for vacuum tubes, particularly for use with thoriated cathodes

[d] Over copper.

continued

Clad and Precoated Metals—continued

Surface ↓	Base Metal		Coating or Cladding		Critical Functions, Properties	Typical Applications
	Metal	Form	How Applied	Thickness, Finish		
Silver						
Silver	Copper, nickel	Wire, 0.005–0.250 in. Also ribbon	Clad by plating, drawing	0.1–25 mils (½–5% by weight)	Atmosphere resistance. High temperature oxidation resistance. Electrical conductivity. Low cost base	High temperature coils, high frequency conductors, braiding for radar cables, strings for musical instruments
Silver	Aluminum (1100, 5052)	Strip, 0.010–0.062 in.	Clad by pressing, rolling	10% of thickness on each side, or 20% on one side. Also 90/10, 70/30, 5/90/5	Electrical contact properties. Electrical conductivity. Lightweight, low cost base. Decoration	Conductors, contacts in aircraft electrical equipment; costume jewelry
Silver	Aluminum, brass	Tubing, seamless rectangular	Clad by pressing, rolling	0.005 in. on inside	Electronic transmission characteristics. Low cost base	Waveguides for electronic transmission lines
Silver	Beryllium, copper (25)	Strip, 0.010–0.015 in.	Clad by pressing, rolling	15% of thickness on all or part of one or both sides	Electrical contact properties. Electrical conductivity. Base has good spring properties, fatigue life	Contact arms for buzzer circuits, other current-carrying springs
Silver	Copper, brass	Strip, 0.010–0.020 in., temper rolled	Clad by brazing, rolling	1 or more mils on part or all of one or both sides. May be edge-laid, inlaid	Electrical contact properties. Low cost base metal	Electrical contacts, slip rings, flexible waveguides
Silver	Invar	Strip, 0.006–0.008 in., temper rolled	Clad by brazing, rolling	0.2–0.3 mil	Good electrical contact properties. Low thermal coefficient of linear expansion	Television antenna connectors
Silver	Monel, nickel	Strip, 0.008–0.020 in., temper rolled	Clad by brazing, rolling	1 or more mils on part or all of one or both sides. May be edge-laid, inlaid	Electrical contact properties. Resistance to corrosion, wear. Low cost base metal	Electrical contacts subject to corrosive conditions or excessive wear
Silver	Phosphor bronze (A, C, D)	Strip, 0.006–0.040 in., spring temper	Clad by brazing, rolling	Same as above	Electrical contact properties. Electrical conductivity. Base has good spring properties	Electrical contact springs
Stainless Steel						
Austenitic [m]	Copper	Strip, 0.010–0.020 in., annealed	Clad by pressing, rolling	25% of thickness on one or both sides	Resistance to corrosion erosion. Thermal conductivity. Uniform heat transfer. Workable base metal	Heat exchangers for chemical processes
Ferritic [n]	Copper	Strip, 0.025–0.050 in.	Clad by pressing or brazing, plus rolling	20% of thickness on one or both sides	Corrosion resistance. Thermal conductivity. Uniform heat transfer. Workable base metal. Decoration	Pots and pans
Stainless	Steel, carbon or low alloy	Plate, ⅛ to 1¼ in. (double-clad) or to 4 in. (single-clad). Also heads	Clad by direct rolling	Up to 30% of thickness on one side or 15% on each side	Resistance to corrosion, erosion. Workable low cost base metal	Process equipment
Stainless	Steel, low carbon	Sheet, plate, 0.050–0.250 in., annealed. May be polished	Clad by casting, rolling	20% of thickness on one side	Same as above. Decoration	Process equipment, architectural paneling, auto bumpers, grills and trim, cooking utensils, food display cases, hospital sterilizers
Ferritic [n]	Steel, low carbon	Strip, 0.015–0.095 in., temper rolled	Clad by direct rolling	15% on one or both sides	Corrosion resistance. Decoration. Workable, low cost base metal	Cooking utensils, auto bumpers, grills and trim

[m]304, 310 [n]430.

Clad and Precoated Metals—concluded

Surface ↓	Base Metal		Coating or Cladding		Critical Functions, Properties	Typical Applications
	Metal	Form	How Applied	Thickness, Finish		
Tin						
Tin	Steel, low carbon	Sheet, strip, 0.008–0.015 in., temper rolled	Electroplated	0.013–0.053 mil on each side. Also 0.013 mil on one side, 0.053 on other. May be chromate treated	Resistance to atmosphere, chemicals. Good solderability. Strong, low cost base metal	Tin cans for food products, kitchenware, bearings (as base for babbitting), parts to be soldered
Tin	Steel, low carbon	Sheet, strip, 0.005–0.125 in., temper rolled	Hot dipped	0.8-2.0 mils ("common") or 0.080 ("std") mil on each side. Natural or polished	Same as above	Tin cans for food products
Zinc						
Zinc	Steel, low carbon	Sheet, strip, 0.005–0.125 in., temper rolled. Also flat wire	Electroplated	0.01, 0.084 or 0.17 mil on each side. May be phosphate treated	Atmosphere resistance. Galvanic protection. Strong, low cost base metal	Lighting fixtures, venetian blind heads, screen frames, refrigerator parts, sliding door tracks, spools and reels, oil cans, signs, auto window channels
Zinc	Steel, low carbon	Sheet, strip, 0.012–0.172 in., annealed	Hot dipped	0.8-2.0 mils on each side. May be chromate treated	Same as above	Roofing and siding, agricultural equipment, refrigerator and air conditioner parts, auto mufflers
Zinc	Steel, low carbon (ASTM A123)	Plate, bar, strip and shapes; 0.125 in. and thicker	Hot dipped	3 mils or more on each side	Same as above	Same as above
Zinc	Steel, carbon or low alloy (ASTM A53)	Tubing, ⅛–1 in. Pipe, ⅛–12 in. Also conduit	Hot dipped	2 mils or more on each side	Same as above	Water pipe. Electrical and hot air conduits
Zinc	Steel, low carbon	Wire, 0.016–0.500 in.	Hot dipped	0.1–1.0 mil	Same as above	Fencing
Organic Coatings						
Alkyd Baked Enamel	Low carbon steel, aluminum	Strip, 0.005–0.050 in., phosphate coated	Painted	½–1 mil on each side. All colors. Low or high formability types	Decoration, atmosphere resistance	Venetian blind slats, curtain rod brackets, calendar frames, auto dashboards, lighting fixture moldings, awnings
Cellulose Lacquer	Steel, low carbon	Strip, 0.005–0.050 in. May be precoated with copper, brass, nickel or zinc; also phosphate coated	Painted	½–1 mil on one or both sides. Clear, all colors	Same as above	Toys, novelties, display frames, premium items, brackets, auto moldings and trim
All	Steel (incl electrogalvanized, tinplate), aluminum, brass, zinc	Strip, 0.006–0.040 in.	Painted	0.1–2.0 mils on one or both sides. Clear, all colors	Same as above	Toys, buttons, buckles, clips, reflectors, picture frames, eraser shields, bottle caps, movie reels, addressograph plates, ashtrays
Polyvinyl Chloride	Steel, aluminum, magnesium	Sheet, strip, plate, 0.010–0.250 in.	Clad by adhesive bonding with heat and/or pressure	0.008–0.030 in. on one or both sides. All colors, special textures	Decoration. Resistance to atmosphere, chemicals. Abrasion resistance. Formability. Low cost base metal	Business machine housings, auto instrument panels, television cabinets, air conditioner housings and drip pans; acid resistant tanks, ducts and fume hoods
Vinyl Lacquer or Enamel	Low carbon steel, aluminum, brass, zinc	Strip, 0.005–0.050 in. Phosphate coated	Painted	0.4–1.0 mil on one or both sides. All colors	Decoration. Atmosphere resistance. Formability	Bottle caps, lipstick cases, garden tools, toys, battery caps, wall tile, eyelets, flashlight parts

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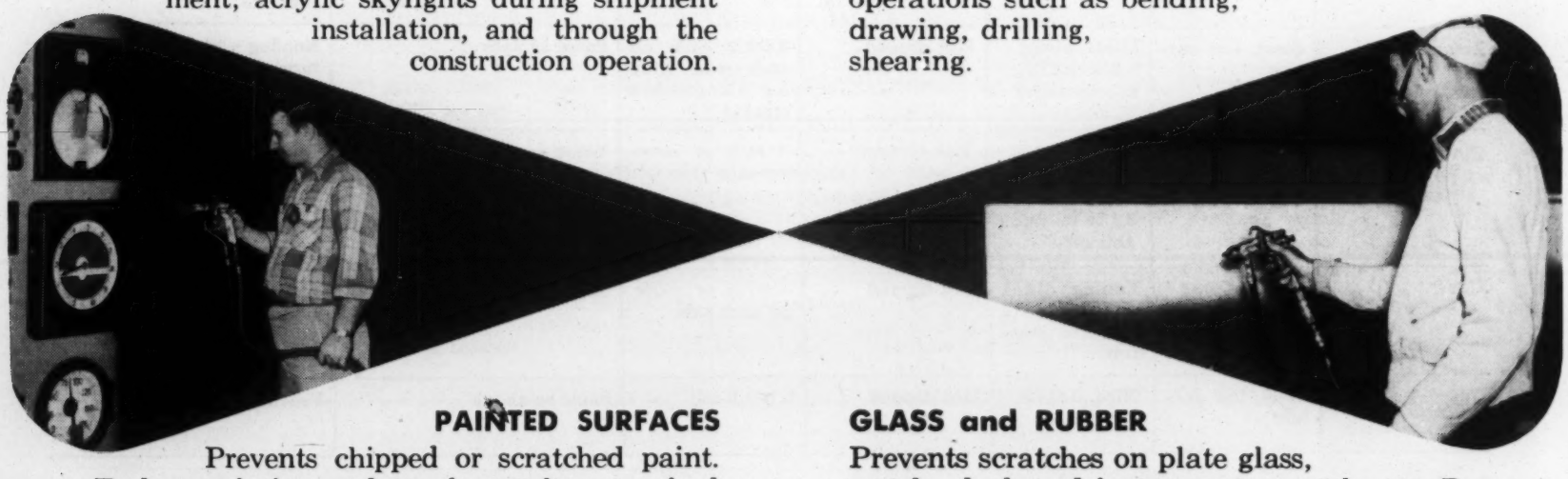

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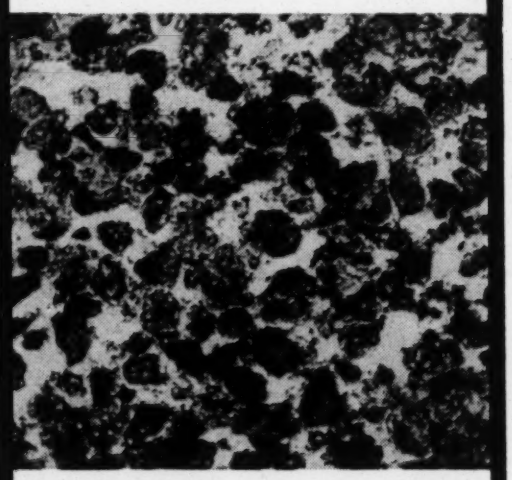

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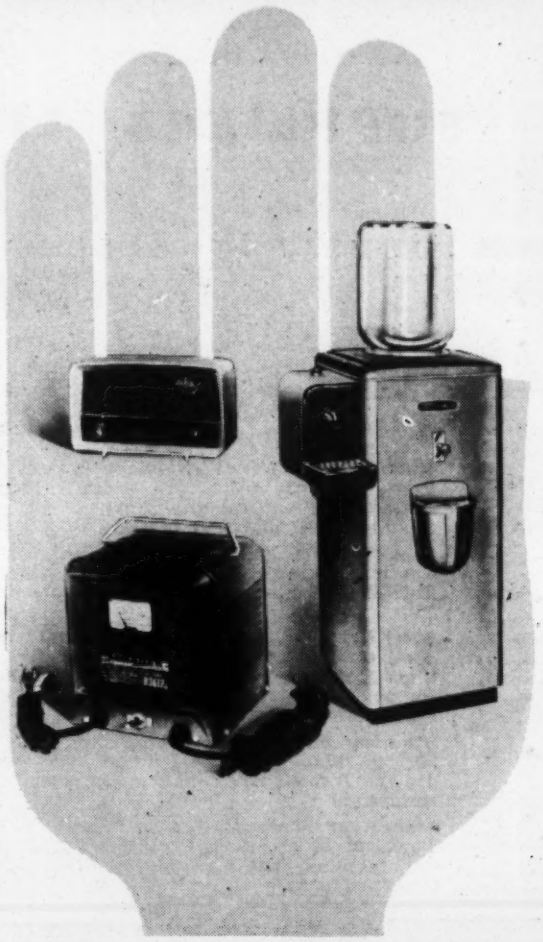

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Steel Tubing. Ohio Seamless Tube Div., Copperweld Steel Co., 8 pp, illus., No. CS-58. Describes carbon and alloy stainless steel tubing in mechanical, aircraft and pressure grades. **296**

Teflon Parts. Crane Packing Co., 4 pp, illus., No. P-327. Describes a line of gaskets, back-up rings and o-rings made of Teflon. **297**

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Forgings. Drop Forging Assn., 1121 Illuminating Bldg., Cleveland 13, 8 pp, illus., No. 2. "Drop Forging Topics" discusses the use of forgings in farm equipment, automobiles and surgical instruments. Write on company letterhead directly to Drop Forging Assn.

Alloy Steel Castings. Duraloy Co., 16 pp, illus., No. 3354-G. Corrosion resistance, uses, chemical composition and physical properties of high alloy steel castings. Castings are of two types—static and centrifugal. **301**

Plastics Parts. Dura Plastics of New York, Inc., 8 pp, illus. Information on the fabrication and availability of plastics advertising displays, lighting fixtures, boat bodies, windshield and instrument panels and dials. Shows company facilities. **302**

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continued on p 366

Forms and Shapes of Materials

	PAGE
Design Features of Metal Forms	294
Castings	296
Extrusions	300
Impact Extrusions	302
Fabricated Sheet Metal Parts	303
Forgings	308
Plastics Parts	311
Metal Powder Parts	316
Screw Machine Parts	318
Spinnings	319
Mechanical Tubing	320
Advertisements	324
Suppliers' Literature	292

Design Features of Metal Forms

Form ↓	Choice of Materials	Complexity of Part	Maximum Size	Minimum Size
Sand Castings	Wide—ferrous and nonferrous metals	Considerable—holes, bosses, locating pads	Great—largest forms made are sand castings	1/8 in. is smallest practicable section
Shell Mold Castings	Wide—same as above excepting low carbon steels	Moderate—limited by mold removal problem	<60 in. square. Best for smaller parts	1/16-in. sections
Permanent Mold Castings	Restricted—brass, bronze, aluminum	Limited—restricted by use of rigid molds	Moderate—50 lb is practical limit in aluminum	1-oz. sections as thin as 0.1 in.
Plaster Mold Castings	Narrow—brass, bronze, aluminum	Considerable—mold destroyed in removal	Moderate—up to 15 lb in most materials	Small—1/32-in. sections possible
Investment Castings	Wide—includes materials hard to forge or machine	Considerable—very few limitations	Moderate—best for parts under 2 lb	Small—sections down to 0.030 in.
Die Castings	Narrow—zinc, aluminum, brass, magnesium	Considerable—though costly dies might be required	Large—up to 75 lb in aluminum, 200 lb in zinc	Sections as small as 0.025 in.
Drop Forgings	Medium—many ferrous, nonferrous alloys	Moderate—limited by die restrictions	Large	Small as fraction of an ounce
Press Forgings	Medium—best for nonferrous alloys	Limited—but greater than drop forgings	Large—300-400 lb a practical maximum	Smaller than drop forgings
Upset Forgings	Medium—many ferrous, nonferrous alloys	Limited to cylindrical shapes	Medium—9-in. bar about largest	Moderate—not comparable to casting
Cold Headed Parts	Narrow—confined to steel, highly ductile alloys	Limited—less flexibility than forgings	Small—7 in. by 1/2 in. dia usual maximum	Small—1/8-in. dia parts can be made
Continuous Cast Parts	Narrow—bronze, nickel bronze	Limited—can be complex in cross section only	Moderate—9 in. max dia	Moderate—5/32 in. for sections
Extrusions	Restricted—light metals, some steels, copper, titanium	Limited—can be complex in cross section only	Medium—8 to 10 in. max dia	Small—0.050-in. sections in aluminum and magnesium
Impact Extrusions	Narrow—aluminum, magnesium, some steel	Limited—must be concentric	Small—6 in. dia in soft alloy, 4 in. in hard	Moderate—3/4 in. dia smallest
Roll Formed Shapes	Narrow—cold rolled steel, some aluminum	Restricted to thin and uniform cross sections	Large	Sections from 0.125 in. up
Stamped and Press Formed Parts	Wide—all workable metals	Moderate—some design restrictions	Large	Small—sections as thin as 0.003 in. possible
Metal Powder Parts	Moderate—iron, steels, nickel, brass, nickel alloys, refractory metals	Limited—powders flow poorly, do not transmit pressure	Small—parts less than 4 in. square best	Small—<1/16 in. dia possible
Spinnings	Wide—many sheet metals	Limited—cylindrical or concentric shapes	Large—up to several feet in dia	Moderate—1/4 in. dia in gages less than 0.040 in.
Screw Machine Parts	Wide—best suited to highly machinable metals	Moderate—limited to rotational shapes	Medium—up to 6 in. long, 2 1/2 in. dia	Small—<1/16 in. dia
Electroformed Parts	Narrow—iron, copper, nickel, silver	Great—extreme complexity possible	Limited—1/2-in. sections can be built up	Small—0.005 in. or less
Tubing	Wide—any ductile metal available in tubular form	Limited by sectional shapes of tubing	Usually 4 to 6 in. o.d.	Moderate—1/4 in. o.d.
Welded and Brazed Parts	Wide—dissimilar metals can be joined	Great—extremely complex shapes	Unlimited	Moderate

	Mechanical Properties	Precision, Tolerances	Special Structural Characteristics	Surface Smoothness	Surface Detail	Remarks
	Fair to high depending upon metal cast	±1/16–1/32 in./in., closer at extra cost	Good bearing structure	Poor	Poor	Usually require some machining before use
	Good—little porosity, few gas inclusions	±0.003–0.005 in./in.	High quality for cast metals	Good	Good	Considered best of low cost castings
	Good—high in centrifugal castings	±0.01–0.05 in.	As above	Good	Good	Large quantities allow production economies
	Fair	±0.010–0.005 in.	—	Good	Good	Little finishing required
	Good	±0.005 in./in. common, ±0.002 in./in. possible	High quality for cast metals	Excellent	Excellent	Best for parts too complicated for other casting
	Fair	±0.001 in./in.	Special properties can be obtained through use of inserts	Good	Good	Most economical where applicable
	High	±0.010–0.030 in. without joining	Grain flow provides toughness	Fair	Fair	Used where high strength is required
	High	±0.005 in.	Hot working gives structural advantages	Fair	Fair	Closer tolerances and greater complexity than drop forgings
	High	Medium—compare to press forgings	Grain flow provides toughness	Medium	Medium	Best suited to small parts
	High	±0.010 in. common, ±0.002 in. possible	Tough structure	High	Fair	High production rates
	Good to high depending on alloys	±1/64 in., closer on rounds	High quality for cast metals	Good	Only as part of contour	Provides long section and complex shapes
	Good	±0.005 in. common	Grain flow improves properties	Good	Only as part of contour	Sometimes used as blanks for other processes
	High—metal cold worked	±0.001 in. common	Grain flow improves properties	Good	Good	Can eliminate machining
	Good	±0.002 in. common	Cold work improves properties	Good	None	Requires large quantities
	Good to high	Good—to ±0.001 in. common	—	High	Good to excellent	Extremely low cost in quan, otherwise moderate
	Fair to good	Good—±0.001–0.005 in. common	Porosity can be controlled and complex materials formed	Fair	Fair	Can use materials not formable by other processes
	Good	Fair—±0.015–0.060 in. common; better at added cost	Grain flow, cold work improve properties	Good	None	Good for large pieces or short runs
	High	±0.001–0.005 in. possible	—	Excellent	Good	High production rates, low cost
	Fair—lower than wrought	High—±0.002–0.0002 in. common	—	Excellent	Excellent	Best when complexity and accuracy essential
	Good—cold working improves properties	Good—depends on quality of tubing	Grain flow improves properties	Good	None	Good means of reducing costs
	Variable—depends upon components	Medium—not highly precise	Can combine parts with special properties	Depends on components	None	Often needed to meet design requirements

Castings

General

Sand castings. These castings are usually the first type considered. A major advantage is their availability in almost limitless shapes and in extreme complexity. Sand castings can be extremely large, but there is a practical limit to their minimum size. The process is not recommended for thin-section castings.

When moderate quantities of a part are required, sand castings can be relatively inexpensive, despite the hand labor required. Practically any metal can be used, with the exception of the newer metals which react with air while in the molten state. For precision parts, sand castings are usually restricted to the light alloys and certain bronzes.

Precision sand castings. Higher accuracy in sand castings is attributable to foundry techniques and closer control over the variables rather than a change in process. Carefully constructed baked sand cores are used when this accuracy is specified, whereas normal green sand molds are used elsewhere.

Most precision sand castings are formed of aluminum and magnesium alloys and the phosphor and tin-bearing bronzes. The as-cast mechanical properties of these castings are approximately the same as those found in conventional sand castings.

Shell mold castings. These castings are formed of any alloy that can be cast in sand, though some casting alloys may be more difficult than others. The low carbon steels tend to have surface defects. Sweating of tin and lead in brasses and bronzes containing a high percentage of these alloying elements has caused problems. The reactivity of magnesium with oxygen and silica sand must be countered with inhibitors or mold washes.

Mechanical properties are comparable to, or better than, those of sand castings. Closer control can be

GENERAL CHARACTERISTICS OF CASTINGS

Type ↓	Cost				Time[c]	Size			As-Cast Finish, rms[e]
	Labor	Equipment[a]	Material	Typical Pouring Rate, per hr[b]		Range	Avg, lb[d]	Min Section Thk, in.	
Sand	High	Die low, tooling high, pattern ¼ of die	Low	25	3–15 days	<1 oz to >200 tons	Few ounces to several tons	Special—1/16, small—3/32–⅛, large—3/16–¼	Requires grinding, polishing, buffing
Precision Sand	Medium high	Low	High	300 per month	4–6 weeks	Max size not known. Present —<1 lb weight to 6 ft length	1–4	0.050	75–80
Permanent Mold	Medium	High	Nonferrous—high, gray iron—low	30	6–12 weeks	1 oz to 600 lb	1–10	0.090	100–125
Plaster Mold	Medium high	Low	High	4–5	4–6 weeks	<1 oz to >100 lb	3–5	0.040–0.060	50
Investment	High	Varies with quality of pattern die necessary	Wide range	Generally low; higher with plastics pattern	4–6 weeks	<1 oz to 25 lb —wax or plastics; >100 lb—frozen mercury	Up to 1	0.030	60—wax and plastics; 40—mercury
Die	Low	High	High	75–150 aluminum, magnesium, copper-base; 300–350 zinc	8–14 weeks	<1 oz to 75 lb aluminum; <1 oz to 200 lb zinc	½–1	0.050	50

[a]Dies, patterns and/or machines.
[b]These figures are general for one set of equipment. Actual rate of casting production depends on number of cavities per mold.
[c]From complete design to production. [d]Average size of competitive castings. [e]Finish obtainable in limited areas.

exercised. Since the shell mold is baked dry, the lack of moisture slightly increases the insulating effect of the mold; the resulting slower cooling of the metal produces better uniformity of structure. The high permeability of shell molds minimizes porosity and voids in the solidified metal by allowing air and gases generated during pouring to escape through the shell.

Permanent mold castings. Parts must be of relatively simple design, but some complexity is possible by using sand cores with steel molds (semipermanent molding). Because of the relatively low temperature limit of the mold material, the process is limited to the lower melting alloys. Aluminum alloys are the most commonly cast. Copper-base alloys, magnesium and, more recently, gray iron are also cast in permanent molds.

Permanent mold castings are usually dense and fine-grained, and can be made with better surfaces and closer tolerances than sand castings. Molds may be preheated to the 700-800 F range to achieve high control. Tolerances must be wider than for die castings, shell mold castings and plaster mold castings.

Plaster mold castings. These castings are noted for their fine finishes which reflect the smoothness of the plaster in which they are cast. The insulating quality of the mold causes a slower cooling rate which results in a reduction of tensile strength and elongation. Although plaster mold castings are used for some high production parts, they are usually considered for small to medium-sized lots. Molding costs are relatively high, but these costs are usually recovered because of the minimum of machining.

Because of the temperature limitations of the mold material, this method is restricted to casting alloys with a melting point below 2000 F. These include aluminum, magnesium, and some of the copper-base alloys, such as yellow brass, silicon bronze, beryllium bronze, aluminum bronze and manganese bronze. Some foundries restrict lead content to 1.5% because of the reactivity of lead with plaster; others claim to have cast 50% lead alloys without difficulty. Alloys containing silicon lend themselves to finer detail with better surface finish. When casting magnesium, special plaster compositions and handling techniques are required, as well as more ample feeding facilities in the mold.

Investment castings. These parts are formed using a pattern molded in wax, plastic, or frozen mercury. Each pattern type has characteristics that make it more suitable for certain parts. Wax permits the greatest flexibility of design and is the least costly. Plastics permit more rapid production of patterns and also allow a surplus of patterns to be stored for future use. Frozen mercury allows larger sizes to be cast and requires only a thin ceramic shell which, in turn, results in better metal quality. In general, investment cast parts offer dimensional tolerances superior to those of other castings, can be made in shapes too complex for metal powder parts, and can be made of metals with melting points too high for die casting. Mechanical properties are generally high.

Of the six types of close tolerance castings (i.e., excluding sand castings), investment castings are matched only by shell moldings in the range of castable alloys available. These alloys include high melting ferrous alloys, copper alloys, special high temperature nonferrous alloys, and all castable aluminum and magnesium alloys. Though the same

MACHINE FINISH ALLOWANCES

Metal ↓	Pattern Size, in.	Bore, in.	Finish, in.
Cast Iron	Up to 12	1/8	3/32
	13 to 24	3/16	1/8
	25 to 42	1/4	3/16
	43 to 60	5/16	1/4
	61 to 80	3/8	5/16
	81 to 120	7/16	3/8
	Over 120	g	g
Malleable Iron[a, b, c, d]	Up to 6	1/16	1/16
	6 to 9	3/32	1/16
	9 to 12	3/32	3/32
	12 to 24	5/32	1/8
	24 to 35	3/16	3/16
	Over 36	g	g
Steel[e]	Up to 12	3/16	1/8
	13 to 24	1/4	3/16
	25 to 42	5/16	5/16
	43 to 60	3/8	3/8
	61 to 80	1/2	7/16
	81 to 120	5/8	1/2
	Over 120	g	g
Brass, Bronze, Aluminum[f]	Up to 12	3/32	1/16
	13 to 24	3/16	1/8
	25 to 36	3/16	5/32
	Over 36	g	g

[a]When castings are constructed so that they warp more than the average amount, the allowances given should be increased.
[b]Disk grinding—only sufficient finish required to take care of draft and possible warpage.
[c]Coin pressing—practically no finish allowance required.
[d]For small parts, an allowance of 1/32–1/16 in. is satisfactory. Larger parts require a slightly greater allowance.
[e]Allowance ranges from 1/8 to 1 in. Values given for finish are normal for ordinary finishes on the drag side. For finished surfaces on the cope side, it is often necessary to double the allowance.
[f]For small or medium-sized nonferrous castings, 1/8 in. is a customary allowance, with correspondingly larger allowances on larger castings.
[g]Special instructions.

continued

Castings—concluded

general degree of accuracy is obtainable with all alloys, it is easier to obtain with the nonferrous alloys because of their higher fluidity and lower melting points.

Die castings. Only nonferrous alloys are suitable for die castings. The range of these alloys is adequate for most needs but more limited than for sand castings. Alloys used, in order of tonnage, are: zinc, aluminum, copper, magnesium, lead and tin. They can be grouped in low and high melting classes according to melting point:

Low melting alloys

Zinc	727 F
Lead	484 F
Tin	417 F

High melting alloys

Aluminum	1115 F
Magnesium	1110 F
Copper	1600 F

The high melting group are usually cast in cold chamber or air injection machines; the low melting alloys in plunger machines. Of all casting processes, die casting is by far the best suited to high production of quality parts. As in permanent mold casting, an advantage is derived from the high thermal conductivity of the steel used in the die. The resultant chilling effect promotes fine grained metallurgical structure. Though die castings are subject to varying degrees of porosity, proper engineering of the casting and die may confine it to noncritical areas.

Design Factors

Draft allowances. Draft allowance is normally at least ½ in. per ft., although it often ranges from ¼ to ⅜ in. per ft. It is seldom less than 1 deg and ⅛ in. per ft. In sand and plaster mold casting, the mold is destroyed; therefore the draft required is only necessary to remove the pattern. Investment casting requires no draft, though ½ to 1 deg can be specified for single parting, noncored dies. Frozen mercury, wax and plastics patterns require no draft, but ½ deg is used with Kirksite dies.

Permanent mold—A minimum of 2 deg on each side is usually provided, though the range is 0 to 3 deg. In recesses, 2 deg on each side is a minimum with 5 deg desirable. The following figures (in. per in. of depth on one side) are fairly standard: magnesium—0.015, aluminum—0.015, bronze—0.020.

Shell mold—Draft angles are not as critical as for permanent mold castings. From ¼ to ½ deg is

DIMENSIONAL TOLERANCES (In.)[a]

Sand Castings	
Gray Iron	1/32–1/16
Malleable Iron	3/32
Steel	5/32
Aluminum Alloys	5/64
Magnesium Alloys	11/64
Brass	3/32
Bronze	1/8
(Zinc, tin, lead not cast)	
Shell Mold Castings	
Ferrous	0.001–0.003 in./in. possible. Commercially 0.010 to 0.015 are held on dimensions within mold half. Across parting line: 0.020–0.030
Magnesium, Others	Same as ferrous
(Zinc, tin, lead not cast)	
Permanent Mold Castings	
Aluminum	0.015 for first inch; then 0.002 in./in. Common total: 0.010–0.050
Magnesium, Gray Iron, Others	Same as aluminum or slightly wider
(Steel, tin not cast)	
Plaster Mold Castings	
Brass, Bronze	0.005 for first inch; then 0.001 in./in. Common total: 0.005 to 0.010
Aluminum, Others	Same as brass and bronze
(Ferrous, zinc, tin, lead, copper not cast)	
Investment Castings	
Copper	0.002–0.005 in./in.
Stainless Steel	0.004–0.008 in./in.
Others	0.003–0.006 in./in.
(Iron, some steels, zinc, tin, lead not cast)	
Die Castings	
Zinc	0.0025 for less than 1 in. 0.001 in./in. for dimensions greater than 1 in.
Aluminum, Magnesium	0.003 for less than 1 in. 0.001–0.002 in./in. for dimensions greater than 1 in.
Others	0.005 for less than 1 in. 0.003 in./in. for dimensions greater than 1 in.
(Ferrous not cast)	

[a]Tolerances are for usual commercial practice, stated for guidance only. In most cases closer tolerances can be held at increased cost. Tolerances are over-all unless stated as in. per in. All values are ± tolerances.

usually sufficient for shell mold castings.

Die—In general, a minimum of 2 deg per side is usually provided. The following draft tolerances (in.) are usually provided:

Magnesium	0.010[a]
Aluminum	0.010-0.015
Zinc	0.005-0.007
Brass, bronze	0.015-0.020
Tin, lead	0.015

[a] In. per in. of depth, one side.

Shrinkage allowances. The following allowances (in. per ft) are usually provided:

Cast iron	1/8
Malleable iron	1/8
Steel	1/4
Aluminum	5/32
Brass	3/16

Design Rules

1. Stress concentration is always a vital consideration. A larger amount of metal will have greater shrinkage and put an adjoining thin section under tension which may result in cracking. The design should incorporate fillets when there is a change of section thickness or to avoid sharp, interior corners. In addition to lowering stress concentration, fillets help achieve even cooling and shrinkage.

2. Continuous, intersecting ribs may cause trouble. Staggering the ribs will help prevent the build-up of high stresses.

3. Avoid large, flat areas with little or no support.

4. The parting line, particularly in die castings, is preferably located at the corner of the casting. Lines of demarcation remaining after flash removal will not be nearly as visible.

MINIMUM SECTION THICKNESS (In.)[a]

Sand Castings	
Gray Iron[a]	1/8–3/16
White Iron	1/8–3/16
Malleable Iron	1/8–3/16
Steel	3/16–1/4
Aluminum	1/8–3/16
Magnesium	3/16–1/4
Brass, Bronze	3/32–1/8
Shell Mold Castings[b]	
Ferrous	1/16–1/8
Magnesium, Others	1/16–1/8
Permanent Mold Castings	
Aluminum	
< 3 In.	3/32–1/8
3 to 6 In.	5/32
>6 In.	3/16
Gray Iron, Others	
<3 In.	3/32–1/8
3 to 6 In.	5/32
>6 In.	3/16
Plaster Mold Castings	
Brass, Bronze	
2 Sq In.	0.040
4 to 6 Sq In.	0.063
<30 Sq In.	0.093
Aluminum, Others	
2 Sq In.	0.040
4 to 6 Sq In.	0.063
<30 Sq In.	0.093
Investment Castings[b]	
Copper	0.030
Stainless Steel	0.050
Others	0.030
Die Castings	
Zinc	
Small	0.020–0.030
Large	0.050
Aluminum	0.035
Magnesium	0.050
Aluminum Alloy	
Small	0.045–0.055
Large	0.080
Magnesium Alloy	
Small	0.050–0.060
Large	0.080
Copper	
Small	0.06
Large	0.10
Brass, Bronze	0.050
Tin	
Small	0.030
Large	0.060
Lead	
Small	0.040
Large	0.070

[a] Usual minimum for various classes of gray iron is: class 20, 1/8; class 25, 1/8; class 30, 1/4; class 35, 3/8; class 40, 1/2; class 50, 1/2; class 60, 3/4.
[b] Avoid section differences where max : min ratio is more than 5 : 1.

Extrusions

General

Extrusions are used extensively as a means of making small parts of uniform cross section that might otherwise be made only through extensive machining. Long pieces of the desired cross section are extruded, then cut to desired lengths and subjected to any further operations that may be required.

Advantages. Extruded shapes are not considered to be highly precise as far as dimensional tolerances are concerned, but they do have the advantage of permitting the metal to be placed where it is most needed to attain desired strength and design characteristics. Relatively complex shapes can be extruded. Sharp corners and reentrant angles are readily obtainable. When precision is a requirement, final dimensions are achieved through machining. Extruding is sometimes used to make blanks for other processes, e.g., forging.

Limitations. Sizes are limited because of the excessive size of the presses required to extrude large sections, and because large shapes are likely to bend and distort excessively under their own weight and require expensive straightening operations. Any openings must be in the direction of the extruding action and uniform throughout the entire length of the extrusion.

Materials. Although in the past most extruded shapes have been made from aluminum, magnesium and copper alloys, the process has recently been expanded to include many types of steels. Steels and other high melting alloys are easy to extrude, but they are hard on die materials and require lubricants with special qualities. Titanium, lead, tin and zinc alloys are also extruded. For best results the ratio of billet size to finished extrusion should be large. When large ratios are used, the resulting extrusions are dense, homogeneous and free of porosity, and the metal properties compare favorably with those attained in forging. Ratios usually range from 20:1 to 40:1.

Speed of output. Rate of output of extruded shapes can affect cost, particularly if large quantities are required. Speeds range from 1½ to 700 fpm, depending on the basic material, the particular alloy and the shape being extruded. Magnesium is extruded at speeds of 4 to 100 fpm, aluminum somewhat faster, and copper alloys a little slower. Highest speeds are attained with nickel alloys and steels.

Applications. Conditions under which extruded shapes might be chosen are:

1. When a more efficient disposal of metal is desirable than is obtainable with rolled shapes or other metal forms.
2. Where several parts are now joined to provide a small assembly.
3. Where shapes are required that could not be obtained without difficult machining.
4. Where short pieces of an extrusion could replace small castings or forgings.

Design Factors

Tolerances. Tolerances on extruded metal parts are held on such factors as straightness, flatness, twist, section thickness, angles, contours, and corner and fillet radii.

Flatness—On a 6-in. width, tolerance would be ±0.024 in., or about 0.004 in. per in. of width.

Straightness—On a 5-ft length, a 1/16-in. deviation from a straight line is normal. This deviation increases to ⅜ in. at 30 ft.

Cross section—Typical are tolerances ranging from ±0.006 in. on thicknesses of less than 0.125 in. up to ±0.080 in. on thicknesses or widths of 14-15 in.

Cut ends—Permissible deviation from the square is 1 deg.

Curved surfaces—Allowable deviation from a specified contour is 0.005 in. or 0.004 in. per in. of chord length, whichever is greater. This tolerance does not apply to an arc of more than 90 deg.

Section thickness. Thickness of sections usually ranges from 0.050 in. up to several inches. Ratios of thickness to width vary with materials used and are standardized for aluminum and magnesium extrusions. Aluminum alloys, such as 3003 and 6063 have a ratio of 8 in. wide to 3/32 in. thick; for 2014, it is 8 in. wide to ⅛ in. thick.

Design Rules

1. Extruded shapes are usually restricted to those that can be contained within a circumscribing 17-in. circle. Within this range, parts can be made as solid, hollow or semihollow shapes; T, L or V sections; rectangles; and complex shapes.
2. Avoid extremely thin sections within a large circumscribing area.
3. Avoid semihollow sections with unbalanced die tongues.
4. Avoid sections with extreme thickness variation.
5. Avoid hollow shapes having unsymmetrical voids or inadequate thickness between voids.

Stepped Extrusions

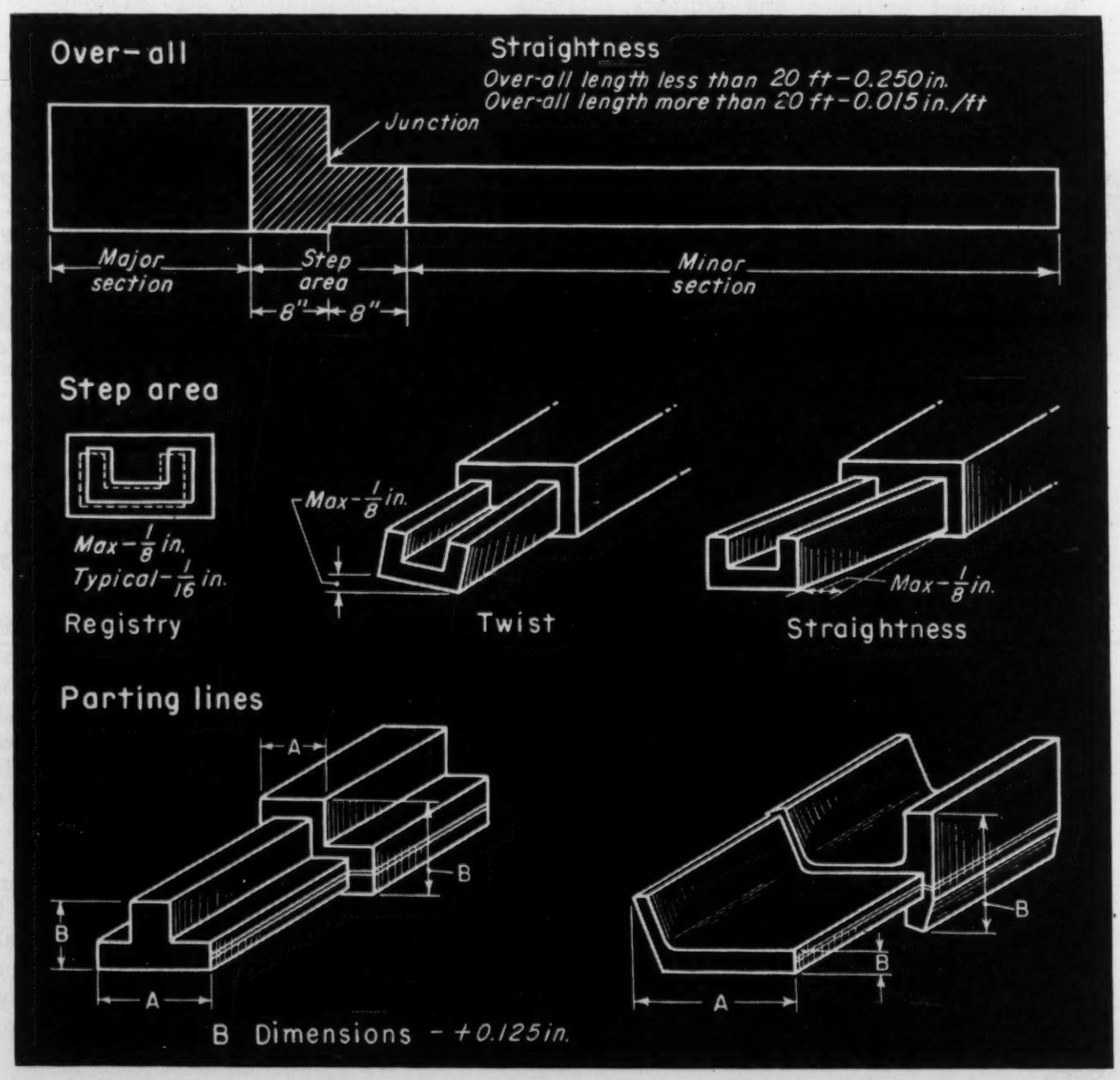
Stepped extrusions are commonly produced by utilizing two sets of extrusion dies.

In designing a stepped extrusion it is important to use dimensional tolerances that are realistic, yet avoid an excess of stock. Stepped extrusion tolerances have not been standardized, but those given in the accompanying sketches are typical. Straightness tolerances differ from those for normal extrusions. In addition, special tolerances apply to the step area and across the parting line when split dies are used.

Because of the inherent instability of split dies, cross section tolerances of stepped extrusions are usually greater than for normal extrusions. In locating parting lines, it is important to consider not only tolerances but also the ability to remove tools from the section. It is sometimes necessary to provide slight draft angles on extended elements.

Although the major and minor sections may frequently have a common plane, this is not a requirement of the process. In all cases, however, the major section must completely enclose the minor section. It is generally necessary to provide machining stock on all surfaces to obtain the required dimensional accuracy and surface finish.

Straightness of the over-all part is measured by deviation from a reference line, the junction or step area (8 in. on either side of the step) being excluded. Straightness of the minor or major portion of the extrusion is determined individually. Because of the difference in flow conditions in extruding the major and minor sections, the junction area usually presents the greatest straightening problems. Minor and major portions are usually furnished to standard extrusion straightness tolerances.



Impact Extrusions

General

Parts made by impact extruding cannot be very large or very small. They must be concentric in design, but can be provided with lugs, flutes and similar projections. Mechanical properties of impact extruded parts are usually high because of the tremendous amount of cold work involved in the process; this is particularly true of carbon steels.

Often a concentric impact extrusion is sectioned after forming to make two or more parts which could not otherwise meet the design requirements of impact extrusion. Examples are semicircular and U-shaped pieces.

Comparisons. Both impact extrusion and deep drawing use a combination of punch and die to form a hollow shell from a cold blank, and for some parts equivalent speeds are used. The difference lies in the manner in which deformation occurs. In impact extrusion the metal is forced through an orifice between punch and die under compressive stresses; in deep drawing the metal is pulled into the die by the punch and stressed in tension.

Both impact extrusion and ordinary extrusion force metal through a die under compressive stresses. However, the metal is generally cold worked in impact extrusion and hot worked in ordinary extrusion. In addition, impact extrusion produces a single component that may or may not require further operations, whereas ordinary extrusion generally produces a continuous cross section such as a rod, tube or structural shape.

An impact extruded part can be considered as a modified forging in which the flash forms the side walls. The part has a base that, in backward extrusion at least, is a forging, and side walls that are extrusions.

Advantages.

1. High speed production is possible.
2. Unit cost of mass produced parts is low.
3. Materials saving and excellent metal recovery are achieved.
4. Process requires few operations. Ribs, fins, holes, etc., are formed during extrusion.
5. Parts have dimensional uniformity with close diametrical tolerances.
6. Tooling is relatively cheap.
7. Surface finishes on the order of 20 to 70 microinches are obtainable.
8. Bottom thicknesses are independent of wall thicknesses.
9. Parts can be made with zero draft angles and sharp corner radii.
10. Parts have excellent properties; for example, cold formed low or medium carbon steel parts have mechanical properties equivalent to those of heat treated carbon and low alloy steels.

Limitations.

1. Relatively few alloys can be processed commercially at present.
2. Shapes that can be produced are limited.
3. Length-to-diameter ratio is restricted.
4. Maximum size of part is limited by press capacity.
5. Comparatively high equipment costs limit applications to relatively high production runs.

COMMERCIAL SIZE RANGES FOR ALUMINUM IMPACT EXTRUSIONS

Material	Wall Thickness, in.		Diameter, in.	
	Max	Min	Max	Min
1070 (collapsible tubes)...	0.010	0.0035	2½	⅜
1100, 3003.....	½*	0.010	6	¾
Medium Strength Alloys..	½*	0.040	5	¾
High Strength Alloys.....	½*	0.062	4	¾

*Some authorities state that the maximum wall thickness is "not known."

Design Factors

Sizes. Part sizes and dimensional tolerances vary considerably, depending upon the metal. Some typical figures: in aluminum, wall thickness ranges from a maximum of ½ in. down to 0.010 in. in the soft alloys or 0.062 in. in the stronger alloys. Diameters of parts can be as great as 6 in. in the soft alloys and 4 in. in the hard alloys, and as small as ¾ in. Larger parts would require extremely high pressures, and smaller parts would involve excessive tool damage.

Tolerances. Typical commercial dimensional tolerances for aluminum are as follows. On walls as thin as 0.10 in., the tolerance can be held to 0.010 in. Over 0.15 in., the tolerance must be increased to 0.020 in. Diameters can be held to 0.010 in., but lengths are not usually guaranteed any closer than 3/16 in.

Materials. By far the most commonly used material for mechanical parts is aluminum and its alloys. More than a dozen different alloys are used, depending upon the end service requirements, but from the standpoint of extruding 1100 alloy is best.

In steels, best results are obtained with those containing up to 1.2% carbon, although several alloy steels are impact extruded regularly. Steel parts must be somewhat smaller and have greater wall thicknesses than similar parts in aluminum.

Magnesium slugs are heated to 500 to 700 F for impact extruding. Several different alloys can be used, but best results are obtained with alloy AZ31B.

Several other metals are impact extruded to a lesser degree. They include lead, tin, copper, zinc and zirconium.

Fabricated Sheet Metal Parts

Stampings and Press Formed Parts

General. Blanking, pressing, stamping and drawing all have certain similarities, and are all done on hydraulic or mechanical presses or drop hammers. Each process consists of shearing or deforming a flat blank of metal sheet or strip in a die.

In making blanked shapes, which are usually flat, the metal is deformed beyond the shear point so that a clean break results. In drawing or forming, the stresses involved exceed the elastic limit of the metal so that permanent deformation results. When extreme draws are required, it is often necessary to draw part of the way, then anneal the metal before making a subsequent draw.

Advantages and limitations. Parts can be fairly complex in shape but the extreme-low-cost advantages diminish with increasing complexity. This is particularly true of designs that include flanges and other projections. Because of the many variables in stamping design the advantages are greatly dependent on the knowledge and skill of the die designer.

Materials. Nearly any metal that can be rolled can be used for stampings and press formed parts; however, materials that are essentially springy in nature should be avoided. Materials commonly used are carbon steels, copper, brass, bronze, aluminum and magnesium alloys, zinc, titanium, nickel alloys, and some high alloy and stainless steels. Stampings can be made with section thickness as little as 0.003 to 0.005 in. but the majority of drawn and stamped shapes are made from thicker materials.

Dimensional tolerances. These vary with the thickness of the material being formed. Tolerances of ±0.001 in. are possible on small pieces, and tolerances on the order of ±0.003 in. are possible on large pieces. These tolerances apply primarily to thin sections; tolerances must be more liberal for thicker sections.

Stamped parts. The width of a projection should be greater than 1½ times the material thickness and never less than 3/32 in.

Pierced parts.

1. The diameter (or smallest dimension) of a hole should be greater than the metal thickness and never less than 0.030 in.
2. Distances between hole edges (or hole edge and blank edge) should be equal to or greater than the metal thickness.
3. Holes pierced near a bending edge should be at least 1½ times metal thickness plus bend radius from the right angle side.

Drawn shapes.

1. Bends in metals should be made as nearly at right angles to the grain or rolling direction of the metal as is possible. Bending across the grain means less likelihood of the metal tearing during drawing.
2. Radii, particularly those on the inside of shapes, should be as large as possible, especially at the bottom of the draw. A radius should always be at

COMPARATIVE FORMABILITY OF METALS[a]

Metal	Alloy	Rating
Aluminum	1100-O	100
	3003-O	95
Magnesium (hot formed)		95[b]
Aluminum	6061-O	92
	5052-O	80
	7075-O	75
	2024-O	75
	2014-O	75
Deep Drawing Steel	1010	75
Soft Copper		75[b]
Commercial Steel	1010	70
Soft Brass		70
Aluminum (as quenched)	7075-W	60
	2024-W	60
	2014-W	60
Aluminum	1100-¼H	50
Stainless Steel	Type 302	49
	Type 304	46
Aluminum	3003-¼H	45
Stainless Steel	Type 321	43
Aluminum	5052-¼H	40[b]
	1100-½H	40[b]
Stainless Steel	Type 347	40
Aluminum	3003-½H	35[b]
	5052-½H	30[b]

[a]Based on rating of 100 for 1100-O aluminum. [b]Tentative.

PENETRATION OF PUNCH THROUGH METAL IN BLANKING OR PIERCING OPERATIONS

Metal ↓	Annealed		Partially Cold Worked	
	Resistance to Shearing, psi	Reduction or Penetration, %	Resistance to Shearing, psi	Reduction or Penetration, %
Lead	3,500	50	—[a]	—[a]
Tin	5,000	40	—[a]	—[a]
Aluminum	8,000	60	13,000	30
Zinc	14,000	50	19,000	25
Copper	22,000	55	28,000	30
Brass	32,000	50	52,000	20
Bronze (90–10)	—	—	40,000	30
Tobin Bronze	36,000	25	42,000	17
Steel				
0.10% C	35,000	50	43,000	38
0.20% C	44,000	40	55,000	28
0.30% C	52,000	33	67,000	22
0.40% C	62,000	27	78,000	17
0.60% C	80,000	20	102,000	9
0.80% C	97,000	15	127,000	5
1.00% C	115,000	10	150,000	2
Silicon Steel	65,000	30	—	—
Nickel	35,000	55	—	—

[a]Anneals at room temperature.

continued

Fabricated Sheet Metal Parts—continued

MINIMUM BEND RADII FOR MAGNESIUM ALLOY SHEET[a]

Alloy ↓	Forming Temperature, F				
	70	300	400	500	600
M1					
Annealed (M1a)	5T	4T	3T	2T	1T
Cold Worked (M1h)	11T	8½T	6½T	4½T	—
AZ31					
Annealed (AZ31Xa)	3½T	2T	1½T	1T	—
Cold Worked (AZ31Xh)	7½T	3T			
AZ51X					
Annealed (AZ51Xa)	6T	4½T	3½T	2½T	2T
Cold Worked (AZ51Xh)	9T	6½T	4½T		

Experimental values, where T=metal thickness.

MINIMUM BEND RADII FOR AUSTENITIC STAINLESS STEELS[a]

Annealed	½T to 1T
¼ Hard	1T to 2½T
½ Hard	2½T to 4T
¾ Hard	3T to 5T
Full Hard	4T to 6T

[a]Where T=metal thickness.

MINIMUM BEND RADII FOR ALUMINUM SHEET[a]

Gage, in. ↓	7075-O, 7075-W[b]	7075-T6	2024-O, 2024-W,[c] 2014-O	2014-T3	2024-T3, 2014-T6	6061-O
0.020..	1/32	3/32	1/64	1/16	1/16	0
0.025..	1/32	1/8	1/64	1/16	3/32	0
0.032..	1/16	5/32	1/64	1/16	3/32	0
0.040..	1/16	3/16	1/32	3/32	1/8	0
0.051..	3/32	1/4	1/16	1/8	3/16	0
0.064..	1/8	5/16	1/16	5/32	7/32	0
0.081..	5/32	3/8	3/32	7/32	9/32	0
0.091..	3/16	1/2	3/32	1/4	11/32	0
0.102..	3/16	5/8	3/32	5/16	7/16	0
0.125..	7/32	3/4	1/8	3/8	1/2	1/16
0.156..	3/8	1	5/32	7/16	5/8	1/8
0.187..	1/2	1¼	3/16	1/2	3/4	3/16

Gage, in. ↓	6061-T4	6061-T6	5052-O	5052-H32 ¼ Hard	5052-H34 ½ Hard	5052-H38 ¾ Hard
0.020..	1/32	1/32	0	0	0	1/32
0.025..	1/32	1/32	0	0	0	1/32
0.032..	1/32	1/32	0	0	0	1/32
0.040..	1/32	1/32	0	0	0	1/16
0.051..	1/16	1/16	0	0	1/32	1/16
0.064..	1/16	3/32	0	0	1/16	3/32
0.081..	3/32	1/8	0	1/32	1/16	1/8
0.091..	1/8	5/32	0	1/16	3/32	1/8
0.102..	1/8	3/16	0	3/32	1/8	3/16
0.125..	3/16	1/4	0	1/8	1/8	1/4
0.156..	5/16	5/16	0	5/32	3/16	1/2
0.187..	3/8	9/16	0	3/16	9/32	9/16

Gage, in. ↓	5052-H38 Hard	1100-H12 ¼ Hard	1100-H14 ½ Hard	1100-H16 ¾ Hard	1100-H18 Hard
0.020..	1/32	0	0	0	1/32
0.025..	1/32	0	0	0	1/32
0.032..	1/16	0	0	0	1/32
0.040..	1/16	0	0	0	1/16
0.051..	3/32	0	0	1/32	1/16
0.064..	1/8	0	0	1/16	3/32
0.081..	3/16	1/32	1/32	1/16	1/8
0.091..	1/4	1/16	1/16	3/32	1/8
0.102..	5/16	3/32	3/32	1/8	3/16
0.125..	3/8	1/8	1/8	1/8	1/4
0.156..	5/8	5/32	5/32	3/16	1/2
0.187..	3/4	3/16	3/16	9/32	9/16

[a]Minimum allowable radii for bending aluminum alloy sheet depend on thickness, temper and composition. Values given in the table are for 90-deg bends and should be increased for bends greater than 90 deg.
[b]Freshly quenched and formed within 2 hr max, or 24 hr max if iceboxed at 32 F.
[c]Freshly quenched and formed within ½ hr max, or 24 hr max if iceboxed at 32 F.

least equal to the thickness of metal being drawn.

3. Radii on the under side of flanges should be at least 1/16 in. in the lightest gages, ⅛ to 5/16 in. in medium thicknesses, and 1½ times the stock thickness in heavy metal.

4. Connecting radii should be larger than the stock thickness.

5. On blanked and shaped parts, depressions should not be deeper than twice the stock thickness. In certain cases, where a hole is permissible, the depressions can be greater because the metal can stretch further.

6. Draws should be as shallow as possible because they are easier to achieve and less costly than deep draws. A draw should never be more than 1½ times the punch diameter.

7. The punch should cover about 50% of the blank area in any draw.

8. Use flat bottoms where possible.

9. Beading, flanging or corrugation can be used to add stiffness.

10. When notching is required, it is done as a final operation so that the notching will not be distorted during the drawing operation.

11. Widest possible tolerances should be provided.

12. In designing shapes, and particularly the tooling required, the springback characteristics of the metals must be considered.

BEND ALLOWANCES IN STEEL SHEET[a]

Inside Bend Rad., in. ↓	Metal Thickness, in.								
	.022	.028	.035	.049	.065	.095	.120	.187	.250
.032	.00072	.00076	.00082	.00093	.00105	.00129	.00148	.00200	—
.0625	.00126	.00131	.00136	.00147	.00160	.00183	.00203	.00255	—
.093	.00180	.00185	.00191	.00202	.00212	.00238	.00257	.00309	—
.125	.00235	.00240	.00245	.00256	.00269	.00292	.00311	.00364	—
.156	.00289	.00294	.00300	.00311	.00323	.00346	.00366	.00418	—
.1875	.00344	.00349	.00354	.00365	.00378	.00410	.00420	.00473	—
.218	.00398	.00403	.00409	.00419	.00432	.00455	.00475	.00527	—
.250	.00453	.00458	.00463	.00474	.00487	.00510	.00529	.00582	—
.281	.00507	.00512	.00517	.00528	.00541	.00564	.00584	.00636	—
.3125	.00562	.00567	.00572	.00583	.00596	.00619	.00638	.00691	—
.343	.00616	.00620	.00626	.00637	.00650	.00673	.00693	.00745	—
.375	.00671	.00675	.00681	.00692	.00705	.00728	.00747	.00800	.00849
.406	.00725	.00730	.00735	.00746	.00759	.00782	.00802	.00854	.00903
.4375	.00780	.00784	.00790	.00801	.00813	.00837	.00856	.00908	.00958
.468	.00834	.00839	.00844	.00855	.00868	.00891	.00911	.00963	.01012
.500	.00889	.00893	.00899	.00910	.00922	.00945	.00965	.01017	.01067
.531	.00943	.00948	.00953	.00964	.00977	.01000	.01019	.01072	.01123
.5625	.00998	.01002	.01008	.01019	.01031	.01055	.01074	.01126	.01175
.593	.01052	.01055	.01061	.01072	.01084	.01108	.01127	.01179	.01230
.625	.01106	.01111	.01117	.01128	.01140	.01161	.01183	.01235	.01284
.656	.01161	.01166	.01171	.01182	.01194	.01218	.01237	.01289	.01339

[a]Allowance for 1 deg of bend; multiply value in table by number of degrees in bend.

BEND ALLOWANCES IN ALUMINUM ALLOY SHEET[a]

Inside Bend Rad., in. ↓	Metal Thickness, in.								
	.020	.025	.032	.040	.051	.064	.081	.091	.128
.032	.00070	.00074	.00079	—	—	—	—	—	—
.0625	.00125	.00129	.00135	.00140	.00149	.00159	—	—	—
.093	.00179	.00183	.00188	.00195	.00203	.00213	.00226	.00234	—
.125	.00234	.00238	.00243	.00249	.00258	.00268	.00281	.00289	.00317
.156	.00288	.00292	.00297	.00304	.00312	.00322	.00335	.00343	.00372
.1875	.00342	.00347	.00352	.00358	.00367	.00377	.00390	.00398	.00449
.218	.00397	.00401	.00406	.00412	.00421	.00431	.00444	.00452	.00481
.250	.00451	.00455	.00461	.00467	.00476	.00486	.00499	.00507	.00535
.281	.00506	.00510	.00515	.00521	.00530	.00540	.00553	.00561	.00590
.3125	.00560	.00564	.00570	.00576	.00584	.00595	.00608	.00616	.00644
.343	.00615	.00619	.00624	.00630	.00639	.00649	.00662	.00670	.00699
.375	.00669	.00673	.00679	.00685	.00693	.00704	.00717	.00725	.00753
.406	.00724	.00728	.00733	.00739	.00748	.00758	.00771	.00779	.00808
.4375	.00778	.00782	.00787	.00794	.00802	.00812	.00826	.00834	.00862
.468	.00833	.00837	.00842	.00848	.00857	.00867	.00880	.00888	.00917
.500	.00877	.00891	.00896	.00903	.00911	.00921	.00935	.00943	.00971
.531	.00942	.00946	.00951	.00957	.00966	.00976	.00989	.00997	.01051
.5625	.00996	.01000	.01005	.01012	.01020	.01030	.01043	.01051	.01080
.593	.01051	.01055	.01058	.01065	.01073	.01083	.01098	.01105	.01133
.625	.01105	.01109	.01114	.01121	.01129	.01139	.01152	.01160	.01189
.656	.01160	.01164	.01170	.01175	.01183	.01193	.01207	.01214	.01245

[a]Allowance for 1 deg of bend; multiply value in table by number of degrees in bend

continued

Fabricated Sheet Metal Parts—concluded

THICKNESS TOLERANCES FOR DRAWN PARTS (In.)

Thickness, in. ↓	Up to 2 In. Dia	Up to 6 In. Dia
1/32	±0.005	±0.008
1/16	±0.006	±0.010
3/32	±0.008	±0.012
1/8	±0.010	±0.015
1/4	±0.015	±0.020

RECOMMENDED MAXIMUM REDUCTIONS IN DRAWING (%)

Low Carbon Steel	45
Austenitic Stainless Steels	50
Copper	45
High Brasses (70–30, 63–37)	50
Tin Bronze	50
Aluminum (annealed, 1/4 hard)	45
Aluminum Alloys	
Annealed, 5052 (1/4 hard)	45
Heat Treatable, As Quenched	40
Zinc	40

MINIMUM PUNCH RADIUS FOR DRAWING CUPS[a]

Ratio of Draw Depth to Draw Dia ↓	Steel		Aluminum	
	SAE 1010	Stainless 302, 304	1100-0, 3003-0 5052-0, 6061-0	2024-0, 2014-0, 7075-0
1/4	1/2T	2T	1T	2T
1/2	1T	—	2T	3T
3/4	2T	—	3T	4T
1	—	—	4T	—

[a]Where T = thickness of material.

Roll Formed Shapes

Roll formed shapes have been produced from material 1/2 to 3/4 in. thick, but usually the material used in roll forming is less than 0.125 in. thick. Roll forming machines are capable of handling sheet and strip varying in width from a fraction of an inch up to as much as 80 in., though most shapes are made from material less than 20 in. wide.

Dimensional tolerances must be comparatively liberal, primarily because of variations in the thickness of the raw material. Usually dimensional tolerances of ±0.002 in. must be allowed.

PERMISSIBLE STRETCH IN STRETCH FORMING THIN-WALLED SECTIONS (%)

Aluminum Alloys	
2024-O, 7075-O	10
2024 (-O, -T or as quenched)	6[a]
6061-O, 5052-O	25
Austenitic Stainless Steels (type 301)	
Annealed	20[b]
1/4 Hard	15–20
1/2 Hard	5–10
3/4 and Full Hard	2

[a]Up to 10% in the web.
[b]Up to 30% for symmetrical and rigid sections.

MINIMUM HOLD-DOWN PRESSURES (Psi)[a]

Low Carbon Steel	500
Austenitic Stainless Steels	1000
Aluminum	100
Aluminum Alloys	200–500
Copper	200
Brasses	250–300
Phosphor Bronze	400

[a]Per unit hold-down area.

Short Run, Press Formed Parts

In the past, stampings and press formed parts could only be considered when huge quantities of parts were required. During the past few years, however, new techniques have been developed to extend the advantages of press forming to relatively small quantities of parts. These methods utilize soft die materials (which are easily worked but have short service lives), rubber blankets, or flexible punches or dies. These materials reduce die costs sufficiently to permit amortization of costs over comparatively small quantities of finished shapes.

Rubber pad. In the rubber pad or Guerin process, a rubber block or pad in the head of the press is used as the second die member to form a sheet metal blank around a punch or form block.

Flexible female die. One method is typified by the Hydroform press, which uses a flexible diaphragm covering a cavity filled with hydraulic fluid. The other method, the Marform press, utilizes a solid rubber pad which holds the blank, while regulated hydraulic pressure allows the punch to move into the pad, forming the part.

Flexible punch. Water or soluble oil is used as the male die member to force the sheet metal to conform to the configuration of the female die.

Drop hammer forming. Zinc-base alloys and lead are normally used for the dies since their low melting points permit rapid and economical fabrication of tools. In simple drop hammer work, there is no hold-down force on the blank; therefore, commonly encountered shapes have flanges and shallow depressions rather than drawn recesses. Parts are formed rather than drawn. Relatively deep draws can occasionally be accomplished with auxiliary devices and fixtures. Reverse contours and saddleback shapes are particularly difficult to form with a drop hammer.

RECOMMENDED LIMITATIONS FOR RUBBER PAD FORMING

Metal ➡	Heat Treatable Aluminum Alloys		Austenitic Stainless Steels	
	0	-T	Annealed	¼ Hard
Max Sheet Thickness, in....	0.187	0.064	0.078	0.032
Recommended Flange Width (straight, not >90 deg), in.[a].....	1/16+ 2.5 T	1/8+ 4 T	3/16+ 4.5 T	5/8
Max Metal Thickness for Forming Flanges, in.				
Stretch Flanges.....	0.125	Special methods required	0.050	0.016–0.030
Lightening Hole Flanges..	0.125	0.064	External 0.060, internal 0.050	External 0.040, internal 0.030

[a]T=metal thickness.

PERMISSIBLE STRETCH IN PRESS-DIE AND HYDROPRESS RUBBER FORMING STRETCH FLANGES (%)

Aluminum Alloys	
2024 (-O or as quenched)	18[a], 12[b]
7075 (-O or as quenched)	18,[a] 12[b]
2024-T	12[a], 8[b]
7075-T	7[a]
6061-O, 5052-O	30
Stainless Steels	
301, 302, 304, 305, 308 (annealed)	40
321, 347, 316, 330 (annealed)	30
301, 302 (¼ hard)	25
301, 302 (½ hard)	10

[a]Routed edge. [b]Sheared edge.

RECOMMENDED SINGLE DRAW LIMITATIONS FOR MARFORM PROCESS

Cup Dia, in. ➡	Max Depth of Draw at Indicated Pressure, in.		Min Thickness, in.
	6000 psi	12,000 psi	
1	1/3	3/4	0.008
2	2/3	1½	0.010
3	1	2¼	0.015
4	1⅓	3	0.020
5	1⅔	3¾	0.025
6	2	4½	0.030
7	2⅓	5¼	0.035
8	2⅔	6	0.040

MAXIMUM CUP DEPTH IN MARFORM PROCESS[a]

Metal Thickness, in. ➡	Max Cup Depth, in.
0.064	5⅛
0.050	4⅞
0.037	4¾
0.032	4½

[a]Based on reduction from 12-in. dia blank to 4¼-in. dia cup, 15,000 psi forming pressure.

Forgings

Cold Headed Parts

General. Cold headed parts are produced in a cold header, essentially a punch press laid on its side. Wire up to about 1 in. in dia is fed into the machine where it is automatically cut to size and positioned in the die with one end protruding from the die face. This end mushrooms out under the force of a punch; the head is formed between the die and punch faces.

Uses. Cold headed parts are economical when mass produced. The majority are mechanical fasteners which are produced at the rate of billions per year by each manufacturer.

Advantages.

1. Grain of the metal follows the contours of the part, avoiding surface weakening.
2. Alloys used are tough, ductile and resistant to cracking.
3. The required corner fillets increase fatigue strength.
4. Surface finish is excellent.
5. No stock is cut away.

Disadvantages.

1. Part must be shaped for extraction from the die.
2. There is a limit to the head volume and shape that can be upset without annealing.
3. Internal stresses may be left at critical points.
4. Size of parts is limited by capacity of cold headers.

Materials. Choice of a metal depends on the heading characteristics of the metal as well as the expected end service. Low and medium carbon steels, some alloy steels and brasses, and some aluminum alloys are most common. Other materials that have been cold headed include: beryllium copper, phosphor bronze, silicon bronze, nickel silver, monel, lead, zinc, silver and gold.

Design Rules

1. Head must taper evenly above and below point of maximum diameter.
2. A widely-spread thin head is more difficult to form.
3. Head heights should be between ¼ and ¾ of wire diameter.
4. Recessed heads require severe forming.
5. Embossing the top of the head increases costs.
6. Concentric heads are easiest to form.
7. Fillets must be provided on corners.
8. Allowable shank reduction is 60% or less.

Tolerances. The best guide to tolerances on cold headed parts are the standards developed by the American Society of Mechanical Engineers for cold headed bolts, screws and rivets. In general, shank diameters are held to ±0.003 in., head dimensions to ±0.005 in., and lengths to ±1/32 in.

Open Die Forgings

Modern open die forging employs mechanical hammers or presses. Each part is heated several times and shaped individually by a highly skilled operator; therefore production rates are low. The major advantages are simplicity of tooling and the wider range of part sizes possible. Shapes are generally simple, and tolerances are much wider than for closed die forgings.

Closed Die Forgings

General. Closed die forgings are produced by shaping hot plastic metal within closed dies; processes include drop, press or upset forging.

Drop forgings—A hammer forces the metal into the die by a series of impact blows. Major advantage is the speed of operation. These forgings are made in weights ranging from less than an ounce to several hundred pounds.

Press forgings—Similar to drop forgings but produced by squeezing in mechanical or hydraulic presses. Particularly adapted to symmetrical parts requiring one or two operations.

Upset forgings—Also produced by squeezing, but the dies grip the stock as well as form the impression. Upset forging is a hot forming process similar to cold heading, but can be used to produce parts weighing from a few ounces up to 500 lb.

Design rules. Dies must shape the part in the easiest possible manner, control the direction of flow, and hold required tolerances. For a large part, several dies may be required. Die blocks are usually made from alloy steel that has been forged to provide uniform properties. Some general design rules are:

1. Divide the impression as equally as possible between the top and bottom dies.
2. Keep the parting line in one plane if possible.
3. Taper the vertical sides to allow removal of the forging.
4. Avoid sharp radii and use fillets where possible.
5. Design ribs as low and wide as possible because they require a corresponding thin pocket in the die.
6. Generous sweeps and maximum draft angles should be provided for sections having a recess because they require that a corresponding raised section be machined into the die. (Raised sections wear rapidly because they get hotter.)

7. Group multiple forgings in die in such a way as to minimize preforming and flash.

8. Where possible, forge two interdependent parts together (e.g., bevel gears and pinions) to reduce die costs and material required.

9. In ring forging, pierce the pancake in such a way that the material removed can be used to produce a smaller ring, thus saving material.

Materials. One of the principal advantages of forgings is the wide range of materials that can be employed. All materials must have these requirements in common: the forging stock (billet, bloom, bar or extrusion) must be hot workable and must be internally sound and free from surface defects. Following is a list of the major classes of forging materials:

Carbon steels—Low carbon (up to 0.25%) forgings for moderate conditions and for carburized parts where resistance to abrasion is important. Medium carbon (0.30 to 0.50%) forgings for more severe service; some heat treatment is generally desirable. High carbon (> 0.50%) forgings for hard surfaces and springs; heat treatment is essential to obtain other desired properties.

Alloy steels—Manganese, nickel, nickel-chromium, molybdenum, chromium, vanadium, chromium-vanadium, tungsten, silicon-manganese. Forgings from these steels are used wherever higher strength, resistance, durability, etc., are wanted. The proper selection of a particular composition, together with its subsequent heat treatment, depends upon the particular service requirements of the part.

Corrosion and heat resisting, and stainless, steels—These steels are usually high in chromium or nickel, or both. The particular type of corroding agent to be encountered determines the best composition. Generally, but not necessarily, forged surfaces should be polished to obtain full benefit of corrosion resistance properties.

Iron—Wrought iron and ingot iron are forged for special applications where ductility is required. Wrought iron furnishes a moderate degree of corrosion resistance. The copper-bearing irons and low carbon steels are in this class.

Copper, brasses, bronzes—Copper forgings have extensive applications in the electrical field. The brass and bronze alloys have moderate corrosion resistance properties. Some of the bronzes have moderately high strength and good bearing properties.

Nickel, nickel-copper alloys—Pure nickel is forgeable. The alloy of nickel and copper known as monel metal offers a desirable combination of strength, toughness and corrosion resistance.

Light alloys (aluminum, magnesium)—The light alloys have about one-third the weight of steel, and some have approximately the strength of low carbon steel. Forgeable alloys are available in both the aluminum and magnesium groups.

Titanium—Titanium and its alloys have been forged for the production of aircraft components. Special dies are necessary and intricate forgings require more stages than steel.

Commercial forging practice. Impression die forgings are sold by the piece and not by the pound. It is understood without specific mention that the excess metal or flash of forgings shall be removed by trimming, and that forgings shall be free from injurious defects.

Quantity—The quantity specified permits standard practice limits on over-runs and under-runs.

Size—Forgings within commercial size limits will be furnished unless closer tolerances are specified.

Coining or sizing—Closer tolerances may be obtained by additional hot or cold sizing operations.

Surfacing conditions—Forgings are furnished in a cleaned condition obtained by tumbling, pickling or blast cleaning unless otherwise specified.

Special requirements—Any special requirement, such as heat treatment or special tests, should be clearly stated.

Preparation charges—The production of impression die forgings requires the preparation of special dies and tools which may be charged to the customer as a separate item called "preparation charges." The

MISMATCHING TOLERANCES ▪

Weight of Part ⬇	Commercial, in.	Close, in.
Net Weight up to—		
1 Lb.....	0.015	0.010
7 Lb.....	0.018	0.012
13 Lb.....	0.021	0.014
19 Lb.....	0.024	0.016
Each Additional 6 lb Add...	0.003	0.002
For Example:		
37 Lb.....	0.033	0.022
55 Lb.....	0.042	0.028

▪Mismatching tolerances are independent of, and in addition to, any other tolerances. Mismatching is the displacement of a point—in that part of a forging formed by one die block of a pair—from its desired position when located from the part of the forging formed in the other die block of the pair. Mismatching does not include any displacement caused by variation in thickness of the forging, but is only the displacement in a plane parallel to the main or fundamental parting plane of the dies.

continued

Forgings—concluded

customer has the exclusive right to use such dies and tools, but because the full cost is generally not included in such a charge he does not have the right to remove them without additional payment. Any such dies and tools are maintained in the future without further charges to the customer.

Tolerances. Standard tolerances given on these pages are for forgings up to 100 lb.

Special tolerances may be specified when regular tolerances are not applicable. Regular tolerances, shown here, are classed as "Commercial Standard" and "Close Standard."

SHRINKAGE AND DIE WEAR TOLERANCES ▪

Length or Width, in. ⬇	Shrinkage		Max Net Wt, lb ⬇	Die Wear	
	Commercial, in. ±	Close, in. ±		Commercial, in. ±	Close, in. ±
1	0.003	0.002	1	0.032	0.016
2	0.006	0.003	3	0.035	0.018
3	0.009	0.005	5	0.038	0.019
4	0.012	0.006	7	0.041	0.021
5	0.015	0.008	9	0.044	0.022
6	0.018	0.009	11	0.047	0.024
For Each Additional Inch Add	0.003	0.0015	For Each Additional 2 Lb Add	0.003	0.0015
For Example:			For Example:		
7	0.021	0.011	13	0.050	0.026
12	0.036	0.018	21	0.062	0.031

▪Shrinkage and die wear tolerances shall not be applied separately. They shall be applied as the sum of the two and shall be measured in such a way as to eliminate draft or variations in draft. They apply to that part of the forging formed by a single die block, and to no dimension crossing the parting plane.

DRAFT ANGLE TOLERANCES

Type ➡	Drop Forgings		Upset Forgings	
	Outside, deg	Inside Holes, deg	Outside, deg	Inside Holes, deg
Nominal Angle	7	7 or 10	3	5
Commercial Limits	0–10	0–13	0–5	0–8
Close Limits	0–8	0–8	0–4	0–7

QUANTITY TOLERANCES ▪

No. of Pieces on Order ⬇	Over-Run, pieces	Under-Run, pieces	No. of Pieces on Order ⬇	Over-Run, %	Under-Run, %
1–2	1	0	100–199	10	5.0
3–5	2	1	200–299	9	4.5
6–19	3	1	300–599	8	4.0
20–29	4	2	600–1249	7	3.5
30–39	5	2	1250–2999	6	3.0
40–49	6	3	3000–9999	5	2.5
50–59	7	3	10,000–39,999	4	2.0
60–69	8	4	40,000–299,999	3	1.5
70–79	9	4	300,000 up	2	1.0
80–99	10	5			

▪Quantity tolerances shall be the permissible over or under-run allowed for each release or part shipment of an order. Any shipping quantity within the limits of over and under-run shall be considered as completing the order. Commercial and close tolerances shall be the same amounts.

THICKNESS TOLERANCES ▪

Max Net Wt, lb ⬇	Commercial, in.		Close, in.	
	Minus	Plus	Minus	Plus
0.2	0.008	0.024	0.004	0.012
0.4	0.009	0.027	0.005	0.015
0.6	0.010	0.030	0.005	0.015
0.8	0.011	0.033	0.006	0.018
1.0	0.012	0.036	0.006	0.018
2.0	0.015	0.045	0.008	0.024
3.0	0.017	0.051	0.009	0.027
4.0	0.018	0.054	0.009	0.027
5.0	0.019	0.057	0.010	0.030
10.0	0.022	0.066	0.011	0.033
20.0	0.026	0.078	0.003	0.039
30.0	0.030	0.090	0.015	0.045
40.0	0.034	0.102	0.017	0.051
50.0	0.038	0.114	0.019	0.057
60.0	0.042	0.126	0.021	0.063
70.0	0.046	0.138	0.023	0.069
80.0	0.050	0.150	0.025	0.075
100.0	0.058	0.174	0.029	0.087

▪Thickness tolerances for drop hammer forgings apply to the over-all thickness measured in a direction perpendicular to the fundamental parting plane of the dies. For upset forgings, thickness tolerances apply to the metal actually enclosed and formed by the dies, measured parallel to the direction of travel of the ram.

FILLET AND CORNER TOLERANCES ▪

Max Net Wt, lb ⬇	Commercial, in.	Close, in.
0.3	3/32	3/64
1.0	1/8	1/16
3.0	5/32	5/64
10.0	3/16	3/32
30.0	7/32	7/64
100.0	1/4	1/8

▪Fillet and corner tolerances apply to all intersection surfaces, even though drawings or models indicate sharp corners. If such drawings or models have or indicate fillet or corner dimensions of larger radii than these standards, such larger dimensions shall be considered as actually specified and the tolerances shall be "special tolerances."

Where a corner tolerance applies on the meeting of two drafted surfaces, the tolerance shall apply to the narrow end of such meeting and the radius will increase toward the wide end. The total increase in the radius will equal the length of the drafted surface in inches, multiplied by the tangent of the nominal draft angle.

Plastics Parts

The form in which plastics materials should be specified is largely determined by the nature of the material. Plastics resins are either thermoplastic or thermosetting in nature. Thermoplastic resins soften and flow when heated and harden when cooled. For moldings, the polymer is usually supplied in granular form. After being heated to the fluid state it is charged to the mold or die, where it cools and hardens.

Thermosetting plastics do not soften when heated, but gradually lose properties as temperature increases, until they char and disintegrate. For moldings, thermosetting resins are usually supplied in a partially polymerized granular form, usually with some type of fibrous reinforcement. They flow to a limited degree on initial heating, but as heating continues they polymerize completely and cure to a hard infusible state.

Molded Parts

Injection molded parts. The injection molding process for plastics is similar in nature to the die casting process for metals. A thermoplastic molding compound is heated to plasticity in a cylinder at a controlled temperature and forced under a pressure of 10,000 to 50,000 psi through sprue, runners and gates into a cool single or multiple cavity mold. The resin solidifies rapidly, the mold is opened, and the part or parts ejected.

The primary advantage of the process, as is the case with die castings, is the relatively low cost per part. Multiple cavity molds can often be used. The cycle is rapid, since parts can be removed from the mold as soon as they solidify sufficiently.

In some cases modifications of the injection molding process can be used to mold small parts of thermosetting resins. These processes are called jet, flow or offset injection molding. They make use of the fluid state of thermosetting molding materials before complete polymerization. The process is suitable only for relatively small parts, and is one that requires careful control of processing variables, such as temperature.

Compression molded parts. Compression molding is primarily used to mold thermosetting plastics, though in some instances it can be used economically to mold thermoplastics, e. g., vinyl phonograph records. Thermoplastic materials cannot usually be preformed, but are charged as powder or granules.

In compression molding, a partially polymerized thermosetting resin, usually in the form of a preform made from powder or granules, is placed in the heated mold cavity. The mold is closed, heat and pressure are applied, and the material flows and fills the mold cavity. The heat then fully polymerizes the material before the mold is opened and the part removed.

In the case of thermoplastic materials, heating softens the polymer, which flows and fills the mold. Then the mold is cooled and the part solidifies.

Less material is required for compression molding than for injection or transfer molding, since the material is placed directly in the mold, and no sprues, runners or gates are required. With thermosetting resins, the cycle is longer than in injection molding, since the part must be cured in the mold.

Cold molded parts. Cold molding is similar to compression molding in that it makes use of a split, or open, mold in which the material is charged. It differs from compression molding in that it uses no heat—only pressure on the order of 2000 to 12,000 psi. After the part is removed from the mold it is placed in an oven to cure to its final state.

Materials used for cold molding are classified as nonrefractory (organic) and refractory (inorganic). Organic types consist of binders — such as asphalts, oil derivatives and residues, and gum or resin solutions — and fillers, such as asbestos fibers and silica and magnesia compounds. Inorganic types consist of binders — such as cement, lime or silica — and fillers, such as asbestos.

Cold molded parts are primarily used for electrical components. The materials have excellent electrical insulating properties, as well as resistance to moisture and heat.

Transfer molded parts. Transfer molding of thermosetting materials is roughly analogous to injection molding of thermoplastics. The thermosetting molding compound is heated to plasticity in a transfer chamber, and is then fed to the mold cavity (or cavities) through sprue, runners and gates. After the mold is filled, heat is maintained for a predetermined period of time to fully polymerize and cure the part.

In comparison with compression molding, transfer molding is particularly advantageous where thin sections or delicate inserts are used. Since the design of runners and gates permits some control over where the material is to be fed to the mold, flow of the material can be more closely controlled than in compression molding. Also, closer tolerances can usually be held on transfer molded parts. On the other hand, transfer molds are usually more elaborate than compression molds, and there is a loss of material in the cull and sprue. Size of transfer molded parts is somewhat limited.

Design factors. Though it is difficult to generalize about design factors for injection, compression and transfer moldings, the following factors should be considered:

Shrinkage—Allowance must be made for shrinkage of the molding compound in design of the part. In addition to affecting dimensional accuracy of the part, shrinkage can introduce internal stress which may make the part unserviceable. Shrinkage values for the various plastics are given in the data sheets in Section 5 of this issue.

Wall thickness—Strength required both in service and during manufacture must be considered in designing wall thickness. In thermosetting materials, walls less than 0.062 in. thick are extremely difficult to obtain, and a minimum of 0.125 in. is preferred (see accompanying table).

Draft—A draft taper in deep drawn parts, in addition to making it easier to remove a part from the mold, creates a wedging action as the the mold is closed. When thermosetting materials are compression molded, converging tapers increase the density of the plastic in the upper sections. There are no precise formulas for taper, but the most liberal taper the design can allow should be provided. Tapers of less than 1 deg can be used for deep parts; e.g., television cabinets 6 to 24 in. deep have been molded with tapers as small as 0.001 in. per in.

Tolerances—A high degree of accuracy in molded parts is expensive to achieve. On small shapes, tolerances as close as ± 0.002 in. are possible. When

continued

Plastics Parts—continued

size is increased to a few inches, over-all tolerances increase to approximately ±0.005 in. On large pieces, tolerances of about ±0.001 to 0.002 in. per in. are obtainable. Tolerances closer than actually mandatory should not be specified; as specified accuracy increases, cost increases disproportionately.

Design Rules.

1. Use sufficient draft on long thin shapes to permit their withdrawal from the mold.

2. Minimize coring. When cores are used they should be easy to withdraw.

3. Avoid internal and external undercuts; they make withdrawal of parts difficult and require considerably more expensive molds.

4. Provide ample fillets on inside corners, and avoid sharp external edges and corners except at the parting line of the die.

5. Avoid large flat areas. Dappling or otherwise breaking up the surface is recommended.

6. Keep tolerances as liberal as possible. Excessively close tolerances add to cost because of increased die costs and high rejection rate.

7. Avoid abrupt changes in wall thickness.

8. Locate parting lines so that flash can be removed easily without marring surrounding areas.

9. Locate holes for easy coring.

10. Use ribs to achieve desired strength and stiffness. Ribs permit materials savings by reducing section thickness.

11. Use inserts for threaded holes where high stresses are anticipated or where considerable wear is to be encountered. Round inserts are preferred.

WALL THICKNESS OF MOLDED PARTS (In.)

Material ↓	Minimum	Small Parts	Average	Large Parts
THERMOSETTING				
Phenolics				
General Purpose & Flock-Filled	0.050	0.062	0.125	0.187–1.000
Fabric-Filled	0.062	0.125	0.187	0.187–0.375
Mineral-Filled	0.125	0.125	0.187	0.200–1.000
Alkyd				
Glass-Filled	0.040	0.093	0.125	0.187–0.500
Mineral-Filled	0.040	0.125	0.187	0.187–0.375
Ureas, Melamines				
Cellulose-Filled	0.035	0.062	0.100	0.125–0.187
Fabric-Filled	0.050	0.125	0.125	0.125–0.187
Mineral-Filled	0.040	0.093	0.187	0.187–0.375
THERMOPLASTIC				
Acrylics	0.025	0.035	0.093	0.125–0.250
Cellulose Acetate	0.025	0.050	0.075	0.125–0.187
Cellulose Acetate Butyrate	0.025	0.050	0.075	0.125–0.187
Ethyl Cellulose	0.035	0.050	0.062	0.093–0.125
Polyamide	0.015	0.025	0.060	0.093–0.125
Polyethylene	0.035	0.050	0.062	0.093–0.125
Polystyrene	0.030	0.050	0.062	0.125–0.250
Polyvinyl Chloride	0.093	0.062	0.093	0.125–0.250

Castings

Materials. Any resin available in liquid form can be cast. Castable resins include phenolics, polyesters, epoxies, silicones and acrylics.

Types of molds. The type of mold used depends on the plastic, the size and shape of the part, and other design considerations.

Draw mold—No undercut is possible. Flutes and scallops must run in the direction of removal. Taper must be provided to break the vacuum and reduce friction. Castings are removed by force, and minimum wall thickness is critical, running from 1/8 in. on tiny parts to 3/16 in. on parts the size of radio cabinets.

Split mold—Undercuts may be provided if they do not prevent release from the separate parts of the mold. Minimum wall thickness is 3/16 in., and parts less than 0.1 lb are not commonly produced economically.

Cored mold—This type allows complexity of design, but is not usually feasible from a cost standpoint for parts less than 4 x 4 x 4 in. Molds require no taper. Minimum wall thickness is 3/16 in. Mold shrinkage allowance must be considered. Extremely large parts may be cast.

Flexible mold—Model may be constructed of wood, porcelain, metal, etc. Mold is of plaster with a lining of rubber latex or an elastomeric plastic. Epoxy materials may be cast in flexible molds, but most polyesters react with the lining material. Although parts cast in rubber molds cannot be held to the tolerances possible with matched metal molds, a reasonable degree of accuracy is reproducible. For example, on cast phenolic parts dimensions can be held to about ±0.004 in. per in. The degree of accuracy obtainable on any part depends on the oversize allowance used in making the master pattern, the care with which the pattern is made, and the degree of accuracy attained in calculating amount of shrinkage during cure of the rubber mold and the cast resin.

Extrusions

In many cases, extruded parts are competitive with molded parts. Where many parts are required with a complicated cross section in one plane, the cross section can be produced by extrusion, and the parts formed by rapid, automatic cut-off to shape.

Thermoplastics. In extruding a thermoplastic, the molding powder is fed through a hopper to a chamber in which it is heated to plasticity at a controlled temperature. The plastic powder is then driven, usually by a rotating screw, through a die having the shape of the desired cross section. The process is continuous and is used to produce tube, rod, film and sheet, as well as other continuous shapes.

Thermosets. Reinforced thermosetting tube and rod can be produced by an extrusion process. The reinforcing fibers are fed continuously through a bath of liquid thermosetting resin and then through a die of the desired cross section. The extruded shapes then pass through a cylinder held at a controlled temperature to polymerize and cure the thermosetting resin. Extrusion speed must be relatively slow to provide sufficient time for complete cure.

Thermoplastic Sheet Formed Parts

Materials. A variety of shapes and forms can be produced by thermoforming calendered, cast or extruded thermoplastic sheet. The materials that lend themselves to this method of forming include polystyrene and modified polystyrenes, acrylics, cellulose acetate and cellulose acetate butyrate, vinyl polymers and copolymers, and polyethylene. Use of this type of molding has grown with the development of relatively low cost extruded sheet to replace more expensive cast or calendered materials.

Methods. Essentially, thermoforming involves preheating the flat sheet to 180 to 360 F, the temperature depending on the material, and then forming by mechanical, air or hydraulic pressure to the desired shape. After cooling, the part is taken from the mold, and unwanted flanges are sawed or blanked from the part. All of the different processes have in common low forming pressures, and thus low cost molds and equipment (see accompanying box for details on the types of parts producible by each method). In recent years, rapid-cycle forming machines have been developed to make sheet molding more practical for large production quantities.

Reinforced Plastics Moldings

The term "reinforced plastics moldings," as used here and in the plastics industry, refers to parts produced by impregnating a reinforcing material, in the form of cloth or mat, with a liquid thermosetting or thermoplastic resin, laminating the material into multiple layers, and curing with heat and pressure to form a dense, hard solid. It does not include materials discussed later as "high pressure laminates," which are available from stock as flat sheet, rod or tube.

Materials. Resins used for reinforced plastics moldings include polyesters, phenolics, epoxies, melamines and silicones. Reinforcements include cloth or mat made from cotton, glass, asbestos and nylon. Glass reinforcements are most commonly used. Recently, there has been much interest in reinforcing thermoplastic resins, such as vinyls and acrylics, with cloth or mat made from thermoplastic synthetic fibers such as nylon. However, the bulk of reinforced plastics moldings today utilizes thermosetting resins.

Methods.

Contact molding—A low cost mold is used. Layers of reinforcing material are placed by hand against the mold surface; and resin is added, either by spraying or brushing after each layer is located. After sufficient layers of mat or cloth have been saturated with resin, they are allowed to harden without external application of heat and without applied pressure.

Vacuum bag molding—Procedure is similar to contact molding except that when lay-up is completed, a flexible sheeting, usually polyvinyl alcohol, is placed over the impregnated reinforcement and a vacuum is drawn between the sheeting and the mold surface. This provides about 12 psi pressure on the part, permitting higher glass content.

Pressure bag molding—Similar to vacuum bag molding except that a tailored bag is placed against the sheeting, and pressure is applied inside the bag to expand it against the impregnated reinforcement (sometimes pressure is applied directly on the sheeting). Pressures up to 50 psi are usually used, making high glass contents practical. Sometimes the entire assembly is placed in a large autoclave that contains hot air or steam at 50 to 100 psi pressure ("autoclave molding").

Flexible plunger molding—A metal female mold is usually employed and glass and resin are placed in the heated cavity. The plug portion is made of medium hard rubber, and is the approximate shape of the part to be molded. The rubber plug provides uniform, high and fluid pressure. High glass contents are possible. This method is not practical for large moldings because of the high pressures and the limitations of the flexible plunger.

Vacuum injection molding—Two molds, often made of glass-reinforced plastics, are used. The reinforcement is laid between the two molds and the resin is poured in a moat around the bottom. The resin is then sucked by vacuum up through the reinforcement. This tends to give air-free parts, and is used primarily for large parts. Glass contents are usually low.

Matched die molding—Can be used for parts up to about 60 sq ft in area, and is generally used for high production runs. Uses two metal molds which have a close-fitting, telescoping area to seal in the resin and trim the reinforcement. The molds are heated (with steam or electricity) to about 240 F. Where the length of run is sufficient, this method gives the lowest cost moldings and the highest production rates.

Design rules. Designing molded reinforced plastics parts is difficult because of the large number of variables encountered in the material and the process, and the difficulty of controlling some of them. These variables include: 1) composition of the resin, including fillers, catalysts and hardening agents, 2) geometry of the reinforcing material, 3) resin-reinforcement ratio, 4) degree of saturation of reinforcement by resin, and 5) temperature and time of cure.

The cardinal design rule, which cannot be overemphasized, is: consult the custom molder in the primary design stages. In addition, follow these general design rules:

1. Integrate parts.
2. Make prototypes.
3. Mold to dimensions; parts cannot be "sprung" after they are molded.
4. Use stress formulas valid for fiber-reinforced plastics.
5. Know the conditions of use.
6. Consider effects of the molding procedure.
7. Use sandwich construction for maximum strength-to-weight ratios.
8. To increase rigidity in stressed areas: a) increase the glass loading, b) use unidirectional reinforcement where practical, c) place flanges and lips on edges, d) use ribs, corrugations, beads and dimples, e) increase wall thickness. f) use curved sections rather than flat areas where possible, and g) use sandwich construction.
9. Avoid drastic changes in wall thickness.
10. Avoid sharp corners; use liberal radii.
11. Use maximum draft.
12. Avoid undercuts.

continued

Plastics Parts—concluded

Thermoplastic Sheet Forming Methods

Cold bending. Simple circular or cylindrical shapes. The thicker the sheet, the larger the bend diameter must be to prevent high stress concentrations. Ex: consumer packages.

Hot line bending. Two-dimensional shapes with arc, angle or channel cross section. Gradual to sharp bends, depending on heating procedure. Ex: safety guards.

Stretch forming (hot draping, yoke forming). Two-dimensional or slightly compound shapes, especially large shapes. Subject to surface distortion. Not suitable for reproduction of fine details. Yoke forming provides more uniform thinning out and is suitable for longer runs than manual stretch forming. Ex: aircraft canopies.

Plug and ring forming. Shallow to deep drawn shapes with gradual to sharp angles and curves. Not suitable for highly accurate contours or fine mold details. Considerable surface distortion, especially at inside corners — unsuitable where optical properties are critical. Ex: trays.

Slip forming. Same as yoke forming or plug and ring forming except that much more uniform thickness and less optical or pattern distortion can be obtained throughout the part, especially in deep drawn shapes. Fluted edges obtained by increasing clearance. Ex: carrying cases.

Free blowing or free vacuum forming. Somewhat modified surface tension shapes (tending toward fishbowl shapes) determined by shape or clamping ring and depth of draw. Internal flanges. Tolerances ¼-½ in. Good optical properties. Vacuum method easier to control and preferred where 15 psi is sufficient pressure. Ex: aircraft domes.

Ridge forming. Simple or complex (with vacuum and/or air pressure) shapes with minimum surface distortion and low mold cost. Generous radii necessary to avoid tearing at ridges during forming. Combines possibilities of plug and ring forming, free blowing or free vacuum forming, vacuum forming and vacuum snapback forming. Ex: equipment housings.

Vacuum forming or blow molding in female mold. Usually limited to relatively shallow draws, and relatively large angles and radii—more so the thicker the sheet. Blow molding offers higher pressures and is therefore more suitable for smaller angles and radii, especially in thicker sheet; also reduces forming temperature required for thick sheet. Both produce some surface distortion—less so the more the shape of the mold resembles a surface tension shape. Ex: display signs.

Blow-dieing. Small, thin shapes having greatest perimeter larger than neck — especially closed spherical or modified spherical shapes. Not suitable for close tolerances. Ex: hollow toys.

Vacuum forming over male plug (drape forming). Shallow to deep drawn shapes with relatively sharp angles and curves can be made with good accuracy and reproduction of fine mold detail, and without excessive thinning out. More accurate than plug and ring forming but not as suitable for thick sheet. Subject to surface distortion, especially at bottom of draw. Ex: display signs.

Vacuum snapback forming. Especially suitable for modified surface tension shapes with minimum mark-off and closer tolerances (⅛ in.) than obtainable in free blowing or free vacuum forming. Simple snapback method not suitable for reverse curves or sudden contour changes, but more complex shapes and finer reproduction of mold detail are provided by additional vacuum or air pressure. Integral flanges. Combines possibilities of free vacuum forming and plug and ring forming. Ex: aircraft domes.

Matched die molding (embossing). Especially suitable for shallow draws, long runs and embossed surfaces. Relatively uniform thickness, good mechanical properties. Subject to surface distortion on both sides. Ex: watch crystals.

Die pressing. Small, simple shapes that can be approximated in precut blank and have somewhat varying thickness, or relatively great thickness compared to over-all size. Ex: brush backs.

13. Consider use of molded-in holes.
14. Consider mold shrinkage.
15. Design to practical dimensional tolerances.
16. Design to avoid warpage.

Secondary fabrication. See "High Pressure Laminates" below.

High Pressure Laminates

The term "laminates" used here refers to those reinforced plastics materials formed by high pressures (over 1000 psi). Vulcanized fibre is also included because of the similarity of its applications. These materials are available as sheet, rod or tube.

Materials. Resins used include phenolics, melamines, silicones and epoxies, and reinforcements consist of

MINIMUM COLD BENDING RADII FOR RIGID VINYL SHEETS

Calendered		Planished	
Thickness, in.	Min Bend Rad., in.	Thickness, in.	Min Bend Rad., in.
0.005			
Long.	½	0.010	12
Trans.	2	0.020	12
0.010		0.030	14
Long.	1	0.040	14
Trans.	6½	0.050	18
0.015			
Long.	3		
Trans.	9		

cellulose paper, asbestos paper, or fabric or mat made from cotton, glass, asbestos or nylon fibers. Vulcanized fibre has only one component—cellulose. It is made by laminating chemically gelled paper, leaching out the chemical, and calendering. The resulting laminate is tough and hornlike, and has good electrical properties. Properties of standard NEMA (National Electrical Manufacturers' Assn.) laminates are given in Section 5 of this issue.

Postforming. Certain grades of laminates can be postformed by the use of heat and pressure. Temperatures, times and pressures vary with grade of laminate, thickness of material, and design. Temperatures generally range between 350 and 480 F, heating time usually ranges from a few seconds to a few minutes at most, and pressures range from a few pounds to several hundred pounds per square inch.

Although the following formability values should not be used for design, they do indicate general limits for postforming. Minimum radii are measured on the inside of bends, and apply to bends made lengthwise and crosswise. Smaller radii can be achieved with cloth-base laminates by orienting the sheet so that bends are made diagonally to the warp and fill directions.

Thickness, in.	Min Bend Rad., in.
1/32	1/32
1/16	3/32
3/32	3/16
1/8	5/16
3/16	9/16
1/4	1
5/16	1 3/4
3/8	2 1/2

Postforming grade laminates can be drawn to moderate depths. Both paper and cloth-base laminates in 1/16-in. thickness can be drawn to a depth of about 1¼ in. in a 3-in. dia spherical cup.

Vulcanized fibre can be formed by the use of moisture and pressure. Water softens or plasticizes the fibre to the extent that it can be formed under relatively low pressures, usually between 200 and 500 psi. In addition to forming in matched die presses, vulcanized fibre can be formed in standard sheet metal angle brakes and in punch presses if the design is simple and only a little moisture is required.

Secondary fabrication. Machining and other secondary operations carried out on reinforced plastics are similar for both low and high pressure moldings, as well as for laminates.

Blanking and punching—Use of a punch press with a hard, well-made blanking or punching die is the accepted production method for cutting flat stock, putting holes into side walls of moldings, and other piercing steps. Punching of reinforced plastics results in holes that are 0.002 to 0.010 in. smaller than the punch. Blanking gives parts 0.001 to 0.005 in. larger than the die. In each case, these values depend on a relation based on the thickness and the proportion of reinforcement. This "shrinkage" causes the material to seize the dies, so that a strongly loaded spring stripper mechanism is desirable. It has been estimated that a pressure of 20,000 psi (on the shear-edge area) is sufficient for blanking, punching and shearing.

Shearing—Shearing of ½-in. thick stock is quite feasible. For best results, the piece should have a width of at least twice the thickness of the parent stock. Shear gibs must be snug and blades sharp.

Sawing—Abrasive cutting wheels should be used whenever possible; rigid mounting of both the wheel and the work is important. A metal cutting blade, if used, should have coarse, offset, wide-spaced teeth.

Drilling—Accurately located holes on side walls are difficult to mold. Where small runs are made, and where precision is required, drilling is recommended. There is no limit to the thickness that can be drilled.

Tapping—Tapping is seldom performed, because the strength of a screw and tapped hole system is inferior to that of a nut and bolt assembly. Where light duty connecting is called for, self-tapping screws are satisfactory.

Grinding—Widely used to provide the taper in glass fiber-reinforced plastics fishing rods. Satisfactory automatic machines are in common use. Standard coolants are employed so that rapid feeds and minimized wheel loading are possible.

Routing, milling, turning—Routing is a practical production edging process and is faster and more accurate than jig-sawing where moderate numbers of irregular holes are to be cut. Milling and turning are not frequently required, but can be readily accomplished. Well-sharpened carbide or diamond-tipped tools provide good efficiency; speeds and feeds appropriate for brass are recommended.

DESIGN FACTORS FOR GLASS-REINFORCED PLASTICS MOLDINGS•

Type of Molding ➡	Bag	Flexible Plunger	Vacuum Injection	Matched Die
Inside Radius (min), in.	½	½	½	⅛
Molded-In Holes	Large only	No	No	Yes
Trimmed in Mold	No	No	No	Yes
Built-In Cores	Yes	Not rec	Yes	Not rec
Undercuts	Yes	Only slight	Not rec	No
Draft (min), deg	5	1	3	1
Thickness (min), in.	1/10	1/16	1/10	1/32
Practical Thickness (max), in.	1	¼	½	¼
Normal Thickness Variation, in.	±0.020	±0.015	±0.020	±0.008
Thickness Build-Up (max)	As desired	2 to 1 max	As desired	2 to 1 max
Corrugated Sections	Core better	Yes, 1-in. rad.	Yes	Yes
Metal Inserts	Yes	Not rec	Yes	Possible
Surfacing Mat	No	Yes	Not rec	Yes
Size of Part (max), sq ft	2000	100	1000	175
Metal Edge Stiffening	Not rec	Not rec	Not rec	Yes
Bosses	Possible	Possible	Possible	Possible
Fins	Yes	No	No	Short, yes
Molded-In Labels	Yes	Yes	Not rec	Yes
Raised Numbers or Letters	Yes	Yes	Yes	Yes

•Not rec=not recommended at present time.

Metal Powder Parts

General

Metal powder parts are made by compacting loose metal powders in a die and subsequently sintering the compact to form a structural part. Additional operations may be used to obtain special results.

Materials. Materials combinations impossible by other processes are commonplace in metal powder parts. Among the materials used are: iron, steel, stainless steel, copper, brass, bronze, monel, nickel, tin, tungsten, zirconium, graphite, and various oxides and carbides. Powders of these materials are produced by a variety of methods, the most common being reduction of oxides or ores, electrolytic deposition, atomizing, mill grinding and thermal decomposition of carbonyls.

Advantages. Powder metallurgy permits the use of metallic combinations that would not be possible to melt, and permits close control over structure, which may be dense or porous as desired.

Limitations. Metal powder parts must be of relatively simple shape because: 1) dies must permit easy removal of parts, 2) most powders have poor flow qualities, and 3) it is difficult to transmit pressures through great depths of powder. Where other considerations make it practicable, more complex shapes can be produced by using costly, intricate dies and double-acting presses. Because powder metallurgy is not capable of holding extremely close dimensional tolerances, secondary sizing or coining operations are sometimes required. Size of metal powder parts is restricted both by available press sizes and by the difficulty of transmitting pressure through powder. Initial tool costs are high. Production volumes of less than 10,000 parts are normally not economical although there are cases where small runs have proved feasible.

Mixing. The powders are mixed with alloying additives and lubricants. In rare cases (e.g., preparation of prealloyed powders) thermal treatment may be required before compacting.

Compacting. Compacting (or pressing) to proper density and shape requires pressures of from 5 to 50 psi in mechanical or hydraulic presses. The dies are usually made of hardened tool steel or cemented carbides and must be lapped to a high polish.

Sintering. This operation is performed at a temperature which is usually 70 to 80% of the melting point of the major constituent. Sintering time ranges from ½ hr to several hours. Volatile materials are driven off and, if present in quantity, can result in porosity. The furnace atmosphere must be carefully controlled to prevent oxidation.

Infiltrating. In this additional step, sometimes desirable, a molten metal of lower melting point than the major constituent is forced into the part under pressure, penetrating and solidifying within the pores. Infiltration increases strength by 70 to 100%.
Other operations. Presintering may be used before parts are machined. Coining (or sizing) is often used to provide closer tolerances and increased strength; pressures used are equal to or greater than the initial pressure. Coining may be followed by another sintering operation. Other operations possible include machining and case or precipitation hardening. A common finishing process is the introduction of oil into the pores of bearings.

Properties of the Powders

The properties of metal powder parts are highly dependent on the qualities of the powders used. The most important of these are:

Purity. Clean particle surfaces insure good contact between particles (needed for optimum mechanical properties). The presence of foreign particles must to be held to a minimum, usually specified.

Apparent density. Apparent density (sometimes bulk density) is the weight of a unit volume of powder and is of particular importance in the pressing operation. The lower the value, the greater the volume of powder needed for a part of given size.

Compressibility. The ability of a metal powder to be pressed is important for both fabrication and end properties. Compressibility (ratio of volume of loose powder to volume of compact) is affected by physical characteristics of powder particles and distribution of particle size.

Particle size distribution. Also called sieve analysis, this property is usually expressed as the percentage by weight of powder that can be retained on each of a series of standard sieves of decreasing size. It affects press feed, dimensional changes during sintering, porosity of the compact, and final attainable density and strength.

Flow rate. The ease with which a metal powder can be fed into the die is determined by its flow rate. Low flow rates slow up automatic pressing operations and may require the use of vibrating equipment.

Sintering properties. Sintering is usually done in an inert, reducing or neutral atmosphere, or in a vacuum. The sintering temperature of metal powders is critical; therefore, for production purposes it is desirable to have a furnace with a reasonably wide temperature range.

Green strength. This is the powder's ability to be handled without breakage after compacting and before sintering.

Properties of the Parts

Mechanical and physical properties of sintered parts are closely related to the final density that can be achieved. In general, as density of a metal powder part increases, strength also increases, and at 100% density the properties theoretically will be at least equal to those of solid stock.

As yet, few standard tests for determining mechanical properties have been established, and in many cases conventional methods are not adequate. In addition, it is not feasible to give detailed information concerning strength properties because they depend on so many variables (e.g., type and size of powder, pressing pressure, sintering temperature, coining and other operations). The table included here is a rough guide to the strength ranges that can be expected with the most common metal powder formulations.

Production Factors

Metal powder parts may be classified in order of increasing difficulty of production according to each of three factors: design, tolerances and density.
Design classification. I—plain circular or profiled parts, II—plain circular or profiled parts with holes,

III—parts with external flanges, IV—parts with internal flanges, V—parts requiring multiple punch motions.

Tolerance classification. a—wide, b—medium, c—narrow.

Density Classification. 1—low (below 6.3 gm per cu cm), 2—medium (from 6.3 to 7.1 gm per cu cm), 3—high (above 7.1 gm per cu cm).

Thus, difficulty in producing metal powder parts ranges from Ia1 to Vc3.

Design Factors

Wall thickness. A wall as thin as 0.030 in. is possible on small parts, but a general rule calls for a minimum thickness of 0.032 in. per in. of length of the section. Large variations in section thickness are undesirable.

Tolerances. There are two different classes of tolerances for metal powder parts: tolerances on dimensions which are tool dependent only, and tolerances that are dependent on both press and tool (generally only the overall dimension in the pressing direction). The accompanying table illustrates that the narrowest tolerances are obtainable only if the last processing step involves a sizing or coining operation, and in some cases a precipitation hardening treatment. These narrow tolerances compare with medium grinding or broaching tolerances. Tolerances for parts that are sintered but not sized compare with medium to wide tolerances for screw machine or milled parts.

Design Rules

1. Cylinders, squares and rectangles are the most favorable shapes. When a shape deviates from these, it is essential that it be uniform in the direction of pressing.

2. Contours must be in a plane at right angles to the direction of pressing.

3. Avoid feather or knife edges; narrow, deep splines; thin projections; and sharp corners.

4. Radii of at least 0.010 in. should be provided in corners, and edges should be given a 45-deg chamfer.

5. Length of part in pressing direction is normally limited to 3 to 6 times the cross sectional area.

6. Use inserts sparingly as they are difficult to mold in.

7. Shoulders in a solid top punch require 1 to 5 deg taper to assist removal.

8. To prevent trapping powder in an acute angle between punch and die, a small horizontal step is recommended.

9. Use flat punches for less breakdown time.

10. An acute angle for a lead-in can sometimes be produced by a coining operation.

11. Undercuts cannot be molded.

12. Parts with multiple steps should be designed with a minimum width of 0.035 in. for each step.

13. Complete spheres cannot be molded.

14. Avoid re-entrant angles.

15. If a projection is opposite the blind end, one or the other must be modified.

16. Grooves in top face of parts can be molded within following limits: 30% of total height for curved grooves, 20% for square. A 5-deg min taper is necessary on vertical sides.

17. Avoid flats on flanges requiring thin punches.

18. Avoid vertical radii on edges.

19. Joining metal powder parts offers special difficulties.

20. Corrosion protection requires special precautions.

TOLERANCES FOR METAL POWDER PARTS

Final Operation ↓	Tolerances, in. per in.[a]		
	Narrow	Medium	Wide
Coining[b]	0.0052, —	0.00208, 0.00132	—, 0.0052
Sintering	—, —	0.00208, 0.00326	0.0084, 0.0208
Case Hardening	—, —	0.00208, 0.0052	0.0208, 0.0208

[a] The first tolerance refers to dimensions which are tool-dependent only; the second to those which are both tool and press-dependent. A dash means the particular class of tolerance is not held.
[b] And possibly precipitation hardening.

PROPERTIES OF SOME COMMON TYPES OF METAL POWDER PARTS

Material[a]	Composition, %	Density, gm/cu cm	Ten Str, 1000 psi	Hardness (Rockwell)	Elong (1 in.), %	Compr Yld Str, 1000 psi[b]
Iron		6.5	22–26	F20–30	2–5	18–21
Iron		7.3	35–38	B15–25	20–28	29–34
Iron-Copper	Cu 1.5–2.5	7.0	35	B30–50	10	26
Iron-Copper-Carbon	Cu 1.5–2.5, C 0.25–0.60	7.0	42	B35–60	7	38
Iron-Copper-Carbon	Cu 1.5–2.5, C 0.6–1.0	7.0	50	B60–80	5	48
Iron-Carbon	C 0.25–0.60	6.5	27	B20–30	2	23
Iron-Carbon	C 0.6–1.0	7.0	48	B55–75	3	45
Iron-Carbon	C 0.6–1.0	6.5	35	B35–45	½	27
Infiltrated Iron	C 0.25	7.3	65	B55–65	1	70
Infiltrated Iron	C 0.6–1.0	7.3	100	B65–75	0.5	120
Stainless Steels	304 and 316	6.0–6.5	40–75	F64–85	12–25	—
Copper		8.3	26–27	H30–40	16–23	20–22
Brass	Cu 77–80, Pb 1.25–1.75	7.8–8.0	27–31	H70–75	15–19	14–18
Bronze	Sn 9.5–10.5	6.8–7.2	16–20	H65–90[c]	2–3	15–20
Nickel Silver		7.7	33	H75–85	16	19

[a] Annealed condition except bronze. [b] At 0.1% offset. [c] Depends largely on degree of cold working.

Screw Machine Parts

General

Advantages. Perhaps the greatest advantage of screw machine parts is the extreme speed at which they can be produced. Production rates can reach—and even exceed—4000 parts per hr. Extremely close tolerances can be held. Finishes are usually superior to those attained by other methods. Since bar or tube stock is used as the raw material, mechanical properties are usually high.

Limitations. Scrap losses are usually high because the over-all size of the bar must be as great, or greater than, the largest diameter of the part.

Materials. Nearly any machinable metal can be used for screw machine parts if it is available in bar or tubular form. For best results, though, the material should be free machining and should not be too soft, too hard or too stringy (since such materials make it difficult to maintain production speeds and also cause inferior surface finish). The majority of screw machine parts are made from free-machining steels, free-cutting brasses, and aluminum and magnesium alloys.

Design Rules

Restrictions are imposed by the requirement that all parts must have surfaces of rotation that are concentric with the axis of the stock being machined. However, interior and exterior undercuts are possible, and nearly any type of thread can be produced.

Square corners are not desirable. Chamfers are preferred, but if rounded edges are desired, liberal radii should be provided. Dimensions can be held to ±0.001 to ±0.003 in. without difficulty and, when necessary, they can be as close as 0.0005 in.

Maximum size is limited, but screw machine parts can be extremely small. The range of sizes normally encountered is ¼ in. up to 8 in. in dia, and a fraction of an inch up to 6-8 in. in length.

MACHINABILITY RATINGS (Based on AISI B1112 = 100)

Aluminum Alloys (wrought)	
3003	Soft
2011	Excellent
2014	Average
2017	Average
2018	Average
2024	Average
6151	Soft
5052	Soft
5056	Average
6061	Soft
6063	Soft
7075	Average
Aluminum Alloys (cast)	
43	Soft
85	Soft
108	Soft
113	Average
122	Excellent
138	Average
142	Average
195	Average
212	Average
214	Average
220	Excellent
319	Soft
355	Soft
380	Soft
750	Excellent
Coppers	
Copper, 99.9%	40
Electrolytic Tough Pitch	40–50
Leaded Copper	160
Oxygen-Free Copper	40
Phosphorized Copper	40
Selenium Copper	180
Tellurium Phosphorized Coppers	180
Copper Alloys	
Aluminum Bronze (alpha), 92–95%	60–80
Copper Alloys (cont'd)	
Aluminum Bronze (duplex)	60–100
Architectural Bronze, 58%	180
Beryllium Copper, 97%	40
Cartridge Brass, 70%	60
Commercial Bronze, 90%—40	
Forging Brass, 60%	160
Free Cutting Brass, 61.5%	200
Gilding Bronze, 95%	40
Gun Metal (cast), 95.8%	60
High Leaded Brass, 62%	180
Leaded Commercial Bronze, 89%	180
Leaded Naval Brass, 60%	140
Leaded Nickel Silver, 46%	160
Leaded Phosphor Bronze (B_1)	100
Leaded Phosphor Bronze (B_2), 94%	200
Leaded Silicon Bronze, 95.6%	120
Low Brass, 80%	60
Low Leaded Brass, 64%	140
Manganese Bronze, 59%	60
Muntz Metal, 60%	80
Naval Brass, 60%	60
Nickel Silvers	40
Phosphor Bronze, 92% (Grades A, C, D, E)	40
Red Brass, 85%	60
Silicon Bronze, 95.8%	60
Irons	
Cast Iron Soft	80
Medium	65
Hard	50
Ingot Iron	50
Irons (cont'd)	
Malleable Iron Standard	120
Pearlitic	80
Wrought Iron	50
Magnesium Alloys (wrought)	500–2000
Nickel and Its Alloys	
Nickel	20
Nickel Alloys (rolled)	40–55
Monel (cast)	35
Monel (rolled)	40–55
Monel, K	40
Screw Machine Steels	
SAE 1120 (leaded)	140
SAE X1112	140
SAE 1112	100
SAE X1314	90–95
SAE X1315	90–95
SAE 1120	70–75
SAE X1335	70–75
SAE X1350	70–75
Carburizing Steels	
SAE X1020	50–65
SAE 1025	50–65
SAE 1020	50–65
SAE 1015	50–65
SAE 6120 (annealed)	45–50
SAE 6115	45–50
SAE 3115	45–50
SAE 4615 (annealed)	45–50
SAE 2315 (annealed)	45–50
SAE 3215	45–50
Heat Treating Steels	
SAE 1035	55–60
SAE 1040	55–60
Heat Treating Steels (cont'd)	
SAE 1045 (annealed)	55–60
SAE 4130 (annealed)	40–50
SAE 4140 (annealed)	40–50
SAE 3140 (annealed)	40–50
SAE 6135 (annealed)	40–50
SAE 6140 (annealed)	40–50
SAE 6150 (annealed)	40–50
SAE 1335 (annealed)	40–50
SAE 1350 (annealed)	30–40
SAE 2330 (annealed)	30–40
SAE 2345 (annealed)	30–40
SAE 3140	30–40
SAE 2345	30–40
SAE 52100 (annealed)	30–40
Stainless Steels	
Type 405	55
Type 406	50
Type 430	50
Type 442	60
Type 443	60
Type 446	65
Type 430-F	90
Type 403	50
Type 410	50
Type 414	60
Type 416	85
Type 420	50
Type 420-F	70
Type 431	54
Type 440	40
Type 501	70
Type 502	70
Type 302	35
Type 303	60
Type 304	45
Type 309	48
Type 316	46
Type 317	45
Type 321	50
Type 347	48
Zinc	200

Spinnings

ADAPTABILITY OF METALS TO SPINNING

Material ↓	Shallow Spinning	Deep Spinning
Group 1—Aluminum and Its Alloys		
1100-O	1.00	1.00
3003-O	1.00	0.99
2024-O	0.65	0.45
5052-O	0.80	0.55
6061-O	0.90	0.80
Group 2—Copper and Its Alloys		
Copper (cold rolled, annealed)	1.00	1.00
Copper (hot rolled)	0.99	0.88
Yellow Brass	0.99	0.92
Cartridge Brass, 70%	0.99	0.92
Low Brass, 80%	0.96	0.89
Red Brass, 85%	0.90	0.83
Commercial Bronze, 90%	0.88	0.80
Gilding, 95%	0.85	0.75
Admiralty	0.82	0.70
Naval Brass	0.75	0.45
Muntz Metal	0.55	0.30
Phosphor Bronze A	0.85	0.40
Phosphor Bronze C	0.85	0.45
Cupro Nickel, 30%	0.95	0.65
Nickel Silver A	0.95	0.65
Silicon Bronze	0.94	0.60
Group 3—Carbon and Low Alloy Steels		
Cold Rolled (deep drawing quality)	1.00	1.00
Vitreous Enameling (deep drawing and spinning quality)	1.00	0.95
Cold Rolled (standard)	1.00	0.92
Hot Rolled (pickled and oiled)	1.00	0.92
Hot Rolled (low carbon)	0.90	0.55
Hot Rolled (copper-bearing)	0.88	0.51
Lead Coated (long terne)	1.00	*
Galvannealed	1.00	*
Galvanized	0.90	*
High Strength	0.45	0.15
Carbon (0.40% and above)	0.25	0.10
Group 4—Stainless Steels		
Type 302	0.98	0.60
Type 304	0.98	0.90
Type 305 (free-spinning)	1.00	1.00
Type 309S	0.80	0.45
Type 316	0.90	0.60
Type 321	0.85	0.50
Type 347	0.90	0.50
Type 430	0.90	0.50
Group 5—Nickel and Its Alloys		
Monel (spinning quality)	1.00	0.90
Monel (special cold rolled, soft temper)	1.00	0.85
Inconel	0.90	0.70
Nickel (low carbon)	1.00	1.00
Nickel	1.00	0.92
Multimet N-155	0.90	0.50
Hastelloy A	0.75	0.35
Hastelloy B	0.70	0.30
Hastelloy C	0.50	0.10
Group 6—Miscellaneous Metals		
Lead	0.96	0.90
Pewter	1.00	0.99
Zinc	1.00	1.00
Tantalum	0.86	0.45
Magnesium	0.80	0.45
Molybdenum	0.55	0.15

*Impractical—coating flakes off.

Cold spinning is done by applying localized pressure to a rotating disk of sheet metal to draw it over a male form. The form is usually of hardwood, sometimes metal, and must be polished smooth or surface roughness will show in the finished part.

Advantages. Simple, economical operation for small-lot production, particularly for shapes that can be withdrawn directly from a one-piece chuck. Multi-section or offset chucks can be used.

Limitations. Considerable skill is required by the operator because the spinning tool (a rounded-end wood or metal tool, or roller) is held and manipulated manually. Usually there is some thinning of the material.

Design Factors. The tolerances held by spinning operations are often closer than for drawn parts. It is also possible to neck over collapsible forms certain parts that could not be produced by drawing or shaping in positive dies.

Materials. Most metals, with the exception of magnesium and molybdenum, can be cold spun. Metals such as gold, silver, platinum, Kovar, Invar and Illium can be spun but require special handling.

Adaptability. Adaptability of metals to the spinning process is rated in the chart given above. The unit 1.00 is assigned to the type of material in each group that lends itself most readily to cold spinning. The lower the index, the higher the cost. These figures will vary slightly with contour, gage and size.

This analysis applies to manual metal spinning by the cold method. Where quantities warrant special automatic spinning setups, or where existing automatic setups can be used, difficult-to-form metals can be deep spun readily. The deep spinning ratings in the table do not apply under these conditions.

Mechanical Tubing

General

Mechanical tubing is manuactured specifically for further processing into fabricated tubular products. It is of uniform high quality and produced to close tolerances. In addition, it usually has good machining qualities and relatively high finish, and is available in a wide range of materials, analyses, shapes and sizes.

The word "tubing" is used to describe several different products, including pipe and casing; however, it refers more specifically to seamless or welded tubular forms which are manufactured to closer size tolerances than pipe. Another distinction is that practically all pipe is round in section.

Advantages. For some parts, such as relatively long, thin-walled cylindrical objects, tubing is the only answer. On the other hand, there are many uses where tubing competes with bar, punchings, machined parts, weldments and castings. In such cases tubing may offer savings in weight, inherent structural strength, and reduction in fabricating time and costs, particularly in machining operations.

The applications of tubing are extended by its ability to be worked and fabricated into parts by many methods (e.g., bending, swaging, spinning, flaring, machining, joining). Because of this adaptability, it actually serves as a semifinished form which can be further shaped into the finished product. In many applications the forming is of such a nature that the tubing practically loses its identity as such.

Materials. Carbon, alloy and stainless steels; copper and copper alloys; nickel and nickel alloys; aluminum and its alloys; magnesium alloys; and titanium. In addition, specialty tubing is made from a number of other, less common materials.

Types. Tubing is produced either seamless or welded. Seamless has no longitudinal seam (however, seamless tubing is often joined end to end by a circumferential weld). Welded tubing is manufactured from flat stock and has a longitudinal seam. Some of the materials mentioned above can be produced only in seamless or only in welded tubing.

Comparisons. Seamless and welded tubing are alike in many of their characteristics, but differ in others. Welded tubing is made with relatively thin walls. Seamless is produced in a larger range of sizes and wall thicknesses, including heavy walls. Closer wall thickness tolerances can be maintained with welded tubing than with seamless.

In mechanical properties, as-welded tube is about equal to the flat stock from which it is formed. Its properties are generally lower than those of cold drawn seamless tubing because of the improvement in properties resulting from cold work. However, drawn welded tubing compares with seamless in its properties. Both welded and seamless tube are closely comparable in their forming characteristics.

TOLERANCES FOR TITANIUM TUBING[a]

Diameter, in.[b] ↓	Cold Drawn[c]		Extruded	
	O. D. Tol, in.	Wall Thk Tol, %	O. D. Tol, in.	Wall Thk Tol, %
Up to 1½	0.010[d]	10	—	—
1½ to 3½	0.010	10	—	—
3½ to 5½	0.015	10	0.031	14[e]
5½ to 8	0.030	10	0.047	12.5
8 to 10¾	—	—	0.063	12.5

[a] Round tubing. All values ±.
[b] Range is not inclusive of higher value.
[c] Welded or seamless; also welded with weld area cold worked.
[d] Some producers state 0.005 in. here.
[e] 12.5% if wall thickness is over 0.203 in.

Temper and finish. Tubing of most materials is furnished in a number of different conditions or tempers to meet specific forming or service requirements. It is also normally available in at least one or two standard finishes. The finishes depend upon the material and methods of manufacture. Where required, any one of a variety of special finishes can be had on order. For example, tubing can be obtained with a special inside surface, a special outside surface, or both. For applications such as plated parts, or parts requiring exceptionally smooth, uniform surfaces, the tubing can be furnished ground and polished.

Design Factors

Shape. By proper design of the part and careful selection of the shape and size of the tubing, machining and other shaping operations can be cut to a minimum. The most common shape is the round section. Square and rectangular sections are often produced as standard shapes in a wide range of sizes. The following are some of the special shapes that can be produced on order: embossed; fluted outside, plain inside; fluted; hexagon; lip; octagon; pinion (longitudinal serrations on outside); polygonal outside, plain inside; reeded; roped; rope-fluted; rope-reeded; round outside, polygonal inside; and twisted.

Cost. Tubing may cost more than bar stock, but savings in processing often offset additional materials cost. Thus, drilling operations can be eliminated, and drills replaced by simple, less expensive boring tools. Boring can be done faster than drilling; chucking pressures are reduced. There is also less tool wear and fewer tool changes.

Tolerances. Round tubing has three cross-sectional dimensions which must be considered in ordering and fabricating. They are outside diameter (o.d.),

DIAMETER TOLERANCES FOR CARBON AND ALLOY STEEL WELDED TUBING[a]

Diameter, in.[b] ↓	Wall Thickness, BWG	Cold Rolled Carbon Steel				Hot Rolled Carbon Steel		
		Standard Tolerance[c]		Close Tolerance[d]		Standard Tolerance[c]		Close Tolerance[e]
		O.D., in.	I.D., in.	O.D., in.	I.D., in.	O.D., in.	I.D., in.	O.D., in.
¼ to ⅜	22 to 14	0.0025	0.009	—	—	—	—	—
	20 to 14	—	—	0.002	0.005	—	—	—
	16 to 14	—	—	—	—	—	—	0.002
⅜ to ⅝	22 to 16	0.003	0.005	—	—	—	—	—
	20 to 12	—	—	0.0025	0.0025	—	—	—
	16 to 12	—	—	—	—	—	—	0.0025
	14 to 12	0.003	0.009	—	—	—	—	—
⅝ to 1⅛	22 to 14	0.0035	0.005	—	—	—	—	—
	20 to 11	—	—	0.0025	0.0025	—	—	—
	16 to 11	—	—	—	—	0.0035[f]	0.012[f]	0.0025
	13 to 11	0.0035	0.008	—	—	—	—	—
1⅛ to 2	22 to 14	0.005	0.006	—	—	—	—	—
	20 to 9	—	—	0.003	0.003	—	—	—
	16 to 14	—	—	—	—	0.005	0.010	—
	16 to 9	—	—	—	—	—	—	0.003
	13 to 9	0.005	0.008	—	—	—	—	—
	13 to 7	—	—	—	—	0.005	0.015	—
2 to 2½	20 to 14	0.006	0.007	—	—	—	—	—
	20 to 9	—	—	0.004	0.004	—	—	—
	16 to 14	—	—	—	—	0.006	0.012	—
	16 to 9	—	—	—	—	—	—	0.004
	13 to 9	0.006	0.009	—	—	—	—	—
	13 to 6	—	—	—	—	0.006	0.016	—
2½ to 3	20 to 18	0.008	0.012	—	—	—	—	—
	18 to 9	—	—	0.005	0.005	—	—	—
	16 to 14	—	—	—	—	0.008	0.012	—
	16 to 9	0.008	0.010	—	—	—	—	0.005
	13 to 4	—	—	—	—	0.008	0.016	—
3 to 3½	20 to 9	0.009	0.012	—	—	—	—	—
	16 to 14	—	—	—	—	0.009	0.015	—
	13 to 4	—	—	—	—	0.009	0.020	—
3 to 4	18 to 8	—	—	0.006	0.006	—	—	—
	16 to 8	—	—	—	—	—	—	0.006
3½ to 4	20 to 8	0.010	0.015	—	—	—	—	—
	16 to 14	—	—	—	—	0.010	0.017	—
	13 to 4	—	—	—	—	0.010	0.021	—
4 to 5	16 to 14	0.020	0.020	—	—	0.020	0.022	—
	13 to 8	0.015	0.018	—	—	—	—	—
	13 to 4	—	—	—	—	0.015	0.026	—

[a] Round tubing. All values are ±.
[b] Range is not inclusive of lower value.
[c] Flash controlled to 0.005-in. max.
[d] Mandrel flash removed.
[e] Without mandrel. Same values hold for cold rolled close tolerance without mandrel.
[f] Diameter range for this tolerance is actually ¾ to 1⅛ in.

inside diameter (i.d.), and wall thickness or gage. In seamless and drawn welded tubing each of the dimensions may vary independently; therefore it is important to have a knowledge of the tolerances to which the tubing is manufactured. This information can be found in the accompanying tables.

continued

Mechanical Tubing—concluded

WALL THICKNESS TOLERANCES FOR CARBON AND ALLOY STEEL WELDED TUBING[a]

Wall Thickness		Wall Thickness Tolerance, in.[b]	
BWG	In.	Cold Rolled	Hot Rolled
22	0.028	+0.000, −0.003	—
20	0.035	+0.000, −0.004	—
18	0.049	+0.000, −0.004 to −0.005	—
16	0.065	+0.000 to +0.002, −0.004 to −0.007	+0.002, −0.006 to −0.010
14	0.083	+0.000 to +0.002, −0.004 to −0.007	+0.002 to +0.003, −0.006 to −0.012
13	0.095	+0.000 to +0.002, −0.004 to −0.007	+0.002 to +0.003, −0.006 to −0.012
12	0.109	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.006 to −0.012
11	0.120	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
10	0.134	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
9	0.148	+0.000 to +0.003, −0.006 to −0.009	+0.002 to +0.005, −0.008 to −0.012
8	0.165	+0.000 to +0.003, −0.007 to −0.010	+0.002 to +0.005, −0.008 to −0.012
7	0.180	—	+0.002 to +0.005, −0.008 to −0.012
6	0.203	—	+0.002 to +0.005, −0.010 to −0.013
5	0.220	—	+0.002 to +0.005, −0.010 to −0.013
4	0.238	—	+0.002 to +0.006, −0.010 to −0.018
—	0.250	—	+0.006 to −0.018

[a] Round tubing.
[b] Ranges are given because tolerance varies with o.d.

TOLERANCES FOR CARBON AND ALLOY STEEL SEAMLESS TUBING[a,b]

Diameter, in.[c] ↓	Finish Annealed		Soft Annealed	
	O.D. Tol, in.	I.D. Tol, in.	O.D. Tol, in.	I.D. Tol, in.
3/16 to 1/2	±0.004[e]	—	+0.006, −0.002	—
1/2 to 1 1/2	+0.005[d,e,f]	−0.005[d,e,f]	+0.008,[d,e,f] −0.002	+0.002,[d,e,f] −0.008
1 1/2 to 3 1/2	+0.010[d,e,f]	−0.010[d,e,f]	+0.015,[d,e,f] −0.005	+0.005,[d,e,f] −0.015
3 to 5 1/2	+0.015[d,f]	+0.005,[d,f] −0.015	+0.023,[d,f] −0.007	+0.015,[d,f] −0.025
5 1/2 to 8	±0.030[f,g]	±0.035[f,g]	±0.060[f,g]	±0.070[f,g]
	±0.020[h]	±0.025[h]	±0.040[h]	±0.050[h]
	+0.030[d]	+0.015,[d] −0.030	+0.045,[d,i] −0.015	+0.037,[d,i] −0.053
8 to 10 3/4	±0.045[f,g]	±0.050[f,g]	—	—
	±0.035[h]	±0.040[h]	—	—
	+0.045[d,i]	+0.015,[d,i] −0.040	—	—

[a] Applies to round cold finished tubing. Wall thickness tolerance is 10% except 15% for 3/16 to 1/2 in. dia.
[b] O.d. tolerances for hot finished tubing: ±0.023 for dia up to 3 1/2 in.; ±0.031 for 3 to 5 1/2 in.; ±0.047 for 5 1/2 to 10 3/4 in. Wall thickness tolerances for hot finished tubing: ±16.5% for wall thickness less than 0.109 in.; ±15% for 0.110 to 0.172 in.; ±14% for 0.173 to 0.203 in.; 12.5% for thicker walls.
[c] Below 8 in., ranges are not inclusive of higher figure.
[d] For tubes which cannot be successfully drawn over a mandrel [often true of those with: 1) i.d. <50% of o.d., 2) wall >25% of o.d., 3) wall >1 1/4 in. thk, 4) weight >90 lb per ft], i.d. tolerance is ±10% of the wall thickness and wall thickness tolerance is 12%.
[e] For certain other tubes which are not commonly drawn over a mandrel (specifically, those with i.d. < 1/2 in., or with i.d. < 5/8 in. when wall thickness >20% of o.d.), the wall thickness tolerance is 15% and the i.d. is governed by the standard tolerances for o.d. and wall thickness.
[f] Tubes with wall <3% of o.d. cannot be straightened properly without distortion and require an additional ovality tolerance of ±1/2% for the o.d. and i.d.
[g] When wall <5% of o.d. [h] When 5% of o.d. < wall <7.5% of o.d.
[i] When wall >7.5% of o.d.

TOLERANCES FOR STAINLESS STEEL TUBING[a]

Diameter, in.[b]	Diameter Tolerances[c]			Wall Thk, in.	Wall Thk Tol for Welded Tubing, in.[d,e]
	Seamless O.D. Tol, in.	Welded			
		O.D. Tol, in.	I.D. Tol, in.		
Up to 3/32	0.005	0.001	0.001	0.025	0.002–0.003
3/32 to 3/16	0.005	0.0015	0.0015	0.032	0.003–0.004
3/16 to 1/2	0.005	0.003	0.005	0.035	0.003–0.005
1/2 to 1	0.005	0.004	0.006	0.042	0.003–0.005
1 to 1 1/2	0.005	0.005	0.007	0.049	0.003–0.005
1 1/2 to 2	0.010	0.006	0.008	0.058	0.004–0.006
2 to 2 1/2	0.010	0.007	0.010	0.065	0.005–0.006
2 1/2 to 3 1/2	0.010	0.010	0.014	0.072	0.005–0.007
3 1/2 to 5	0.015	0.015	0.020	0.083	0.005–0.007
3 1/2 to 5 1/2	0.015	—	—	0.095	0.005–0.007
5 1/2 to 8	0.030	—	—	0.109	0.005–0.007
8 to 8 5/8	0.045	—	—	0.120	0.005–0.007
				0.134 and over	0.007–0.008

[a] Round tubing; annealed or as cold finished. All values are ±.
[b] Ranges are not inclusive of upper values.
[c] Tolerances are general and subject to limitations by D/t ratio. Ovality tolerance is generally double the o.d. tolerance.
[d] Tolerance for seamless is ±10%; 15% when o.d. < 1/2 in.
[e] Ranges are given because tolerance varies with o.d.

TOLERANCES FOR NICKEL AND NICKEL ALLOY SEAMLESS TUBING[a]

Dia, in.	Dia Tol, in.[b,c]	Wall Thk Tol, %[b]
Monel, A Nickel, Low Carbon Nickel		
Up to 5/8	+0.005	12.5
5/8 to 1½	0.005	10
1½ to 4½	0.010	10
4½ to 6	0.015	12.5
6 to 7½	0.020	12.5
7½ to 8⅝	0.025	12.5
Inconel, Inconel X, K Monel, Incoloy		
Up to 5/8	0.005	15
5/8 to 1½	0.0075	10
1½ to 3½	0.010	10
3½ to 4½	0.015	10
4½ to 6	0.020	12.5
6 to 6⅝	0.025	12.5

[a] Round cold drawn. All tolerances ± except where otherwise indicated. Tolerances given here are applicable only to two dimensions at a time. Diameter ranges are not inclusive of lower values.
[b] The following applies only to tubes which cannot be successfully drawn over a mandrel: 1) If i.d. <50% of o.d., the i.d. tolerance is ±10% of the wall thickness and the wall thickness tolerance is 12½% for alloys in top part of table, 15% for others; 2) if i.d. < ½ in., the i.d. will be governed by standard tolerances for o.d. and wall thickness.
[c] Tubes with wall <3% of o.d. cannot be straightened properly without distortion and require an additional ovality tolerance of ±½% for the o.d. and i d. Tubes furnished in soft annealed temper may possess ovality because of warpage during annealing or straightening and will not have tolerances as close as table indicates.

TOLERANCES FOR SMALL DIAMETER TUBING[a]

Dia, in.[b]	O.D. Tol, in.	I.D. Tol, in.
Up to 3/32	+0.002	−0.002
3/32 to 3/16	+0.003	−0.003
3/16 to ½	+0.004	−0.004
½ to 1½	+0.005	−0.005

[a] Wall thickness tolerance is ±10%. These tolerances are general; suppliers specializing in particular materials or sizes often hold closer tolerances for standard tubing.
[b] Range is not inclusive of higher value.

TOLERANCES FOR COPPER AND COPPER ALLOY SEAMLESS TUBE[a]

Dia, in.[d] ↓	Mean Diameter Tolerances, in.[b]		Wall Thickness, in.[e] ↓	Wall Thickness Tolerances, in.[c]	
	Nonrefractory	Refractory		Nonrefractory	Refractory
Up to 1/8	0.002	0.0025[f]	Up to 0.018	0.001 –0.002	0.0015–0.0025
1/8 to 5/8	0.002	0.0025	0.018 to 0.025	0.002 –0.003	0.0025–0.004
5/8 to 1	0.0025	0.003	0.025 to 0.035	0.0025–0.004	0.003 –0.005
1 to 2	0.003	0.004	0.035 to 0.058	0.003 –0.007	0.004 –0.009
2 to 3	0.004	0.005	0.058 to 0.083	0.0035–0.010	0.0045–0.013
3 to 4	0.005	0.006	0.083 to 0.120	0.004 –0.011	0.005 –0.014
4 to 5	0.006	0.008	0.120 to 0.165	0.005 –0.012	0.007 –0.015
5 to 6	0.007	0.009	0.165 to 0.220	0.007 –0.014	0.009 –0.018
6 to 8	0.008	0.010	0.220 to 0.284	0.009 –0.016	0.012 –0.020
8 to 10	0.010	0.013	0.284 to 0.380	0.011 –0.018	0.015 –0.023
			0.380 and over	5–6%	6–8%

[a] Round tubing. All values are ±.
[b] Tolerances apply to i.d. or o.d. except where otherwise indicated.
[c] Maximum deviation at any point; range indicates variation with o.d.
[d] Ranges are not inclusive of lower values. [e] Ranges are not inclusive of upper values.
[f] O.d. only; value for i.d. is 0.003 in.

TOLERANCES FOR EXTRUDED AND DRAWN ALUMINUM TUBING[a]

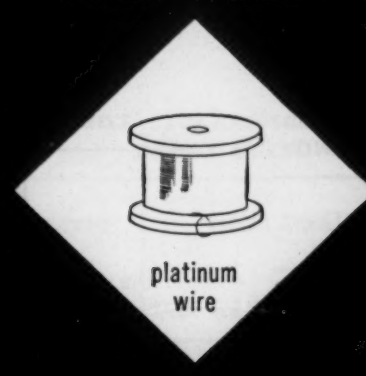
Diameter, in.[b] ↓	Diameter Tol, in.		Wall Thk, in. ↓	Wall Thk Tol, in.[c]	
	Drawn	Extruded		Drawn	Extruded
Up to ½	0.003	—	Up to 0.047	—	0.006
½ to 1	0.004	0.010	0.010 to 0.035	0.002	—
1 to 2	0.005	0.012	0.036 to 0.049	0.003	—
2 to 3	0.006	0.015	0.047 to 0.061	—	0.007–0.010
3 to 4	0.008	0.015	0.062 to 0.077	—	0.008–0.012
4 to 5	0.008	0.025	0.050 to 0.083	0.004	—
5 to 6	0.010	0.025	0.078 to 0.124	—	0.009–0.015
6 to 8	0.015	0.035	0.084 to 0.120	0.005	—
8 to 10	0.020	0.045	0.121 to 0.203	0.006	—
10 to 12	0.025	0.055	0.125 to 0.249	—	0.009–0.020
12 to 12.875	—	0.065	0.204 to 0.300	0.008	—
			0.250 to 0.374	—	0.011–0.025
			0.301 to 0.375	0.015	—
			0.375 to 0.499	—	0.015–0.035
			0.376 to 0.500	0.020	—
			0.500 to 2.000	—	0.020–0.075

[a] Round tubing. All values are ±.
[b] Range is inclusive of upper value for drawn tubing, lower for extruded.
[c] Allowable deviation of mean from specified wall thickness.

TOLERANCES FOR EXTRUDED MAGNESIUM TUBING[a]

Dia, in.[b]	Mean Dia Tol, in.	Wall Thickness, in.[b] ↓	Mean Wall Thk Tolerance, in.		
			O.D. to 2.99	O.D. 3.00–4.99	O.D. >5.00
Up to ½	0.008	Up to 0.062	0.007	0.008	0.010
½ to 1	0.010	0.063 to 0.124	0.008	0.010	0.015
1 to 2	0.012	0.125 to 0.249	0.009	0.013	0.020
2 to 4	0.015	0.250 to 0.374	0.011	0.016	0.025
4 to 6	0.025	0.375 to 0.499	0.015	0.021	0.035
6 to 8	0.035	0.500 to 0.749	0.020	0.028	0.045
8 to 10	0.045	0.750 to 0.999	—	0.035	0.055
10 to 12	0.055	1.000 to 1.499	—	0.045	0.065

[a] Round. All values are ±. [b] Ranges are not inclusive of higher values.



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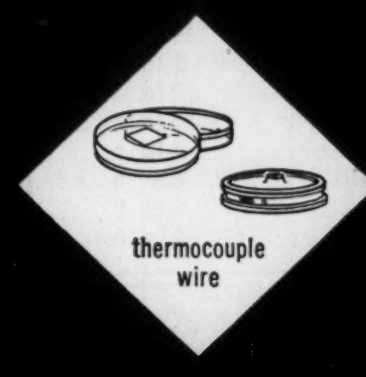

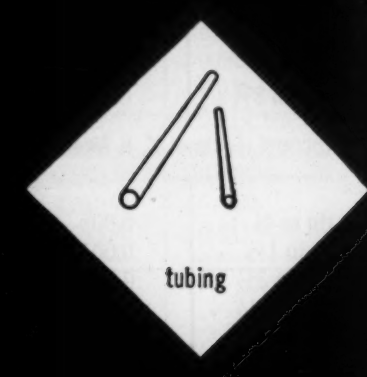

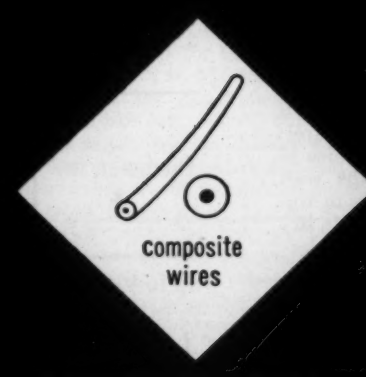

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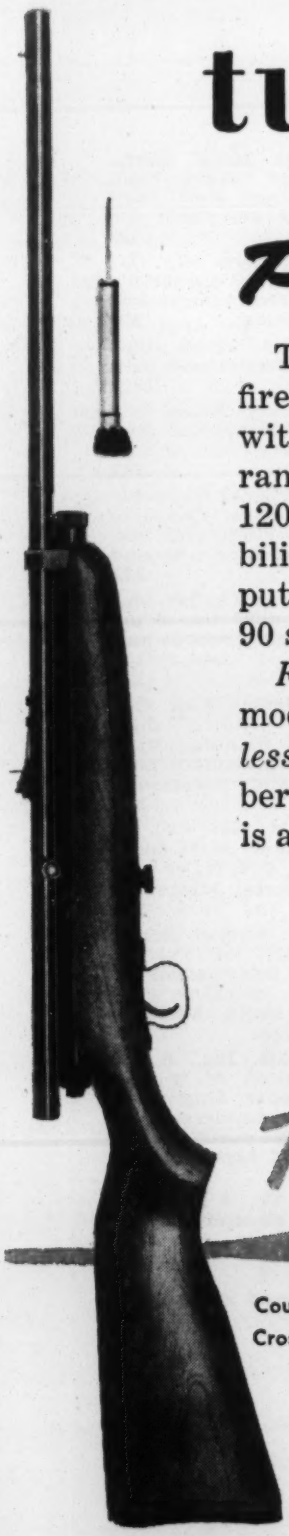

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continued from p 292

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continued on p 369

continued from p 366

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Zinc Die Castings. St. Joseph Lead Co., 25 pp, illus. Discusses role of zinc as a base metal for die casting alloys and lists commercial finishes for zinc-base die castings. **351**

Centrifugal Castings. Sandusky Foundry & Machine Co., 12 pp, illus. Specifications, chemical composition and physical properties of ferrous and nonferrous metals used in the company's centrifugal castings. **352**

Nonferrous Castings. Shenango Furnace Co., Centrifugally Cast Products Div., 4 pp, illus., No. 154. Chemical analysis and physical properties of tin bronzes, brass, silicon bronzes and special alloys for use as centrifugal castings. **353**

Welded Tubing. Standard Tube Co., 8 pp, illus. Describes stainless steel pipe and tubing; mechanical steel tubing; and boiler, condenser and other pressure tubing. **354**

Titanium Tubing. Superior Tube Co., 8 pp, illus., No. 44. Chemical composition and mechanical and physical properties for titanium tubing. Information on flaring, machining, heat treating and brazing. **355**

Steel Castings. Unitcast Corp., illus., No. 649A. Discusses testing facilities for insuring high quality production of steel castings. **356**

Metal Powder Parts. U. S. Graphite Co., Div. of Wickes Corp., illus., No. 21. Properties, uses and dimensions of Gramix metal powder parts. **357**

Cold Formed Parts. Van Huffel Tube Corp., 48 pp, illus. Information on cold formed metal parts. **358**

Stainless Steel Castings. Waukesha Foundry Co., Castings Div., 8 pp, illus., No. SS. Physical properties and uses of martensitic, ferritic and austenitic stainless steel castings. **359**

Synthetic Rubber Products. Western Felt Works, Acadia Synthetic Products Div., 6 pp, illus. Shows various types of molded, extruded, die cut and lathe cut synthetic rubber parts and sheets. **360**

Shell Molded Castings. Westinghouse Electric Corp., Materials Mfg. Dept., 8 pp, illus., No. 52-520. Gives an illustrated, step-by-step description of the shell mold casting process. **361**

Light Metal Forgings. Wyman-Gordon Products Corp., 4 pp, illus. Forgings of magnesium and 7075 aluminum. **362**

Gray Iron Castings. Zenith Foundry Co., 20 pp, illus. Shows how quality control is used in the production of gray and alloy iron. Includes physical properties of gray and alloy irons. **363**

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This issue contains six such cards—enough to help you throughout the year. For the other cards, see pp 405 and 479.

Suppliers' literature available is listed on eight other pages in this issue: 30, 82, 140, 226, 256, 292, 366 and 370.

SUPPLIERS' LITERATURE

Joining and Fastening of Materials

Welding, Brazing Alloys. Air Reduction Sales Co., 48 pp, illus., No. 9-13. Information on ferrous and nonferrous welding rods, brazing fluxes and brazing alloys. **372**

Solders for Semiconductors. Alpha Metals, Inc., 4 pp, illus. Sizes, operating data and properties for a series of lead, tin, indium and aluminum alloy solders for automatic soldering of semiconductors. **373**

Sealing Compounds. Presstite-Keystone Engineering Products Div., American Marietta Co. Pictures and captions show sealing compound applications in the automotive and refrigerator industries. **375**

Bronze Electrodes. Ampco Metal, Inc., illus. Properties and uses of aluminum bronze electrodes and filler rods. **376**

Nylon Fasteners. Anti-Corrosive Metal Products Co., Inc., 4 pp., illus. Elasticity and resiliency, insulation characteristics, and heat and solvent resistance of nylon fasteners. **377**

Epoxy Adhesive. Carl H. Biggs Co., Inc., 4 pp. Physical and chemical properties and uses of a thermosetting epoxy resin adhesive that cures at room temperature. **379**

Fasteners. Boots Aircraft Nut Corp., 6 pp, illus. Information on threaded inserts for sheet metal assembly and other uses. **380**

Adhesives Specs. Borden Chemical Co., Div. of Borden Co., 10 pp. Adhesives coatings, sealers and vinyl tubing complying with U. S. Government specifications. **381**

Cementable Teflon. Continental-Diamond Fibre Corp., Div. of Budd Co., Inc., 4 pp. Physical and chemical properties, thicknesses, bonding techniques and uses for glass-supported, unsupported and metal-clad cementable Teflon tapes and sheets. **382**

Special Fasteners. Buffalo Bolt Co., Div. of Buffalo-Eclipse Corp., 16 pp, illus. Describes and illustrates over 100 special fasteners including hex head bolts, weld bolts and tapping screws. **383**

Fasteners. Camloc Fastener Corp., 4 pp, illus., No. 57. Installation data, uses and dimensions of a fastener that opens and closes in one-quarter turn. **384**

Iron Powder Electrodes. Champion Rivet Co., 8 pp., illus. Mechanical properties and deposition rate of four iron powder electrodes for rutile, low hydrogen, rutile fillet and low hydrogen arc welding. **386**

Rivet Setter. Chicago Rivet and Machine Co., 6 pp, illus. Dimensional data and features of a machine that sets two rivets at a time. **387**

Cap Screws. Cleveland Cap Screw Co., 4 pp, illus. Describes cap screws made of heat treated alloy steel in sizes from 4 to 1½ in. **388**

Lock Fasteners. Continental Screw Co., 4 pp, illus. Installation data for various sizes and shapes of Nylok self-locking screws and bolts. **389**

Adhesives. Cordo Chemical Corp., 24 pp. Properties, uses, application data and prices of adhesives used to bond metals, plastics, wood, glass, paper, cloth and leather. **390**

Grooved Fasteners. Driv-Lok Pin Co., 24 pp, illus. General specifications of grooved fasteners, as well as drilling procedures and hole tolerances for pin applications. **391**

Self-Locking Nut. Elastic Stop Nut Corp. of America, 6 pp, illus. Where and how to use Esna Elastic stop nuts, which are locked on the bolt by the gripping action of the collar. **393**

Screws. Elco Tool & Screw Corp., 4 pp, illus. Information on screws, bolts, threaded and cold headed products. **394**

Silver Brazing. American Platinum & Silver Div., Engelhard Industries, Inc., 16 pp. Manual on selective fluxing for low temperature silver brazing. **395**

Adhesives. Furane Plastics, Inc., 1 p. Briefly describes a family of adhesives for bonding metals, plastics, rubber and ceramics. **398**

Structural Adhesives. General Mills, Chemical Div., 10 pp, illus., No. 11-F-1. Properties, uses, availability and handling information on structural adhesives and sealants based on polyamide resins. **399**

Fasteners. General Tire & Rubber Co., illus. Self-mounting fasteners for shock-mounting metal, plastics and glass panes and components. **400**

Stud Welding. Gregory Industries, Inc., Nelson Stud Welding Div., 24 pp, illus. Discusses stud welding and gives physical properties of various types of studs. **401**

Die Cast Nuts. Gries Reproducer Corp., 3 pp. Standard specifications covering all types of zinc die cast threaded fasteners. **402**

Lock Weld and Clinch Nuts. Grip Nut Co., 12 pp, illus. Specifications and applications for lock, weld and clinch nuts. **403**

Inserts. Groov-Pin Corp. Self-tapping insert used as original equipment and for salvage and repair of stripped threads. **404**

Silver Alloy Brazing. Handy & Harman, 4 pp, illus., No. 78. Case histories on silver alloy brazing of small parts used in missiles, automatic bowling pin devices and power tools. **405**

Arc Welders. Harnischfeger Corp., 4 pp, illus., No. W99-1. Describes a.c.-d.c. arc welders that are suitable for metallic arc, Heliarc, sigma and spot gun welding. **406**

Corrosion Resistant Fasteners. H. M. Harper Co., 84 pp, illus. Sizes and prices for brass, bronze, copper, nickel, monel, stainless steel and aluminum bolts, nuts, screws, washers and rivets. **407**

Cold Headed Fasteners. John Hassall, Inc., 4 pp, illus. Lists possibilities and limitations of cold heading as a high speed, low cost production method for rivets, screws and threaded parts. **408**

Blind Rivets. Huck Mfg. Co., 16 pp, illus. Gives dimensional data and specifications for a line of blind rivets. Charts give Air Force, Navy, and Army Ordnance part numbers. **410**

Adhesives. Angler Adhesives Div., Interchemical Corp., 8 pp, illus. Lists colors, bases, solvents and applications for the company's line of cements and adhesives. **411**

Electrical Tapes. Kendall Co., Polyken Sales Div., 4 pp, No. P6-1. Polyethylene, vinyl, plastics-coated cloth and cloth tapes for electrical applications. **412**

Welding Electrodes. Lincoln Electric Co., 12 pp, illus., No. 7000.1. Physical properties, specifications, welding procedures and sizes for a series of manual electrodes for welding mild, low alloy and high strength steels. **413**

Carbon Dioxide Welding. Liquid Carbonic Corp., Compressed Gas Div., 21 pp, illus. Information on metallic arc-gas shielded welding with carbon dioxide. **414**

Rivets. Milford Rivet & Machine Co., 12 pp, illus. Specifications, applications and design tips for a series of cold formed rivets furnished in semi-tubular and split rivet types. **416**

Specs for Adhesives. Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., 23 pp, illus., No. 8. Military, Army and Federal specifications and corresponding 3M adhesives, coating and sealer that meets these specs. **417**

Steel Fasteners. Nut-Shell Co., 53 pp, illus. Dimensional data, weight, type of material and finish for self-locking, hex, miniature, dome and right angle steel nuts. **418**

Weld Fasteners. Ohio Nut & Bolt Co., 40 pp, illus., No. 58. Dimensions, characteristics and uses of nuts, screws and pins that are applied by resistance welding. **419**

Tapes. Permacel-Lepage's, Inc., 4 pp, illus. Uses of the company's line of acetate fiber, cloth, Mylar, cellophane, paper and electrical tapes. **421**

Pressure Sensitive Adhesive. Pierce & Stevens Chemical Corp., 2 pp. Information on coverage, storage and handling of a pressure sensitive adhesive. **439**

Thermosetting Adhesives. Raybestos-Manhattan, Inc., Adhesives Dept., 4 pp, No. 650A. Uses, shear strength values, heat resistance and application data for thermosetting adhesives. **422**

Film Adhesives. Rubber & Asbestos Corp., 10 pp. Use of two elastomer-phenolic film adhesives for flat-surface bonding of metals and plastics. **423**

Screws. Russell, Burdsall & Ward Bolt & Nut Co., 8 pp, illus. Advantages and specifications of Spin-Lock screws available in hex, pan, truss and flat heads. **424**

Set Screws. Set Screw & Mfg. Co., 28 pp, illus., No. 21. Information on self-tapping and heat treated stainless steel set screws. **425**

Self-Locking Fasteners. Simmons Fastener Corp., 42 pp, illus., No. 1257. Specifications, applications and installation data for special self-locking fasteners. **426**

Thermosetting Adhesive. Honeycomb Structures Co., Inc. Div., Swedlow Plastic Sales Co., 4 pp, illus. Gives typical applications and physical properties of Honeyco Bond 371W, a liquid thermosetting adhesive for metal-to-metal bonding and honeycomb sandwich construction. **430**

Rivets. Judson L. Thomson Mfg. Co., 44 pp, illus. Design information, dimensional data, uses and advantages of semi-tubular, deep-drilled, split, shouldered, precious metal and brass rivets. **431**

Welding Titanium. Titanium Metals Corp. of America, 32 pp, illus. Do's and don't's for successful welding of titanium. **432**

Lockbolts. Townsend Co., 8 pp, illus. Installation data, dimensions, uses, and design data on lockbolts. **433**

Heliarc Welding. Linde Co., Div. of Union Carbide Corp., 8 pp, illus. Shows use of Heliarc welding in fabricating stainless steel exhaust systems, magnesium shell racks, lead flashings and stainless steel exhaust cones for jet engines. **434**

Sigma Welding. Linde Co., Div. of Union Carbide Corp., 8 pp, illus. Sigma welding for joining aluminum, magnesium, nickel, copper and high temperature alloys. **435**

Brazing Alloy. United Wire & Supply Corp., Brazing Alloy Div., 8 pp, illus., No. B-80. Composition, specifications, physical properties and brazing characteristics of a low temperature silver brazing alloy. **436**

Brazing Stainless Steel. Wall Colmonoy Corp., Stainless Processing Div., 4 pp, illus. Information on brazing and processing of stainless steel, titanium, aluminum and low carbon steel parts. **437**

Nylon Screws. Weckesser Co., 3 pp, illus. Properties and uses of black nylon screws and nuts. **438**

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Joining and Fastening of Materials

PAGE

Joinability of Materials 372

Brazing and Soldering Alloys 374

Welding Rods and Electrodes 378

Adhesives 386

Mechanical Fasteners 389

Advertisements 393

Suppliers' Literature 370

4

Joinability of Materials[a]

Material ↓	Arc Welding	Oxyacetylene Welding	Resistance Welding	Brazing
Cast Iron	Common by shielded metal arc where ductile weld not required	Rec with cast iron rods; braze welding if no corr or thermal stress	Seldom; if used, flash welding preferred	Dfclt; easiest for quality-controlled and Ni-cont types
Carbon and Low Alloy Steels	Rec for low carbon and low alloy, common for medium, dfclt for high; all processes	Rec with rods of same comp for low carbon, low alloy; incr C makes more dfclt	Rec for low carbon and low alloy; flash and upset used as C incr dfclt	Rec for low, medium carbon; dfclt for high; seldom for heat treated alloy steels
Stainless Steel	Rec for 200 and 300 series, common for 400 series; all processes	Common for thin gages, dfclt for thicker	Rec for 300 series; 400 series susceptible to hardening	Rec with silver brazing alloys
Aluminum, Magnesium	Common by inert gas; Al slightly easier than Mg	Common for Al <1 in., Mg & M1 alloy; others dfclt	Common; Mg more dfclt, though spot welding used	Common for Al alloys and Mg alloy M1
Copper and its Alloys	Common by inert gas; electrolytic Cu joints not high str	Common for most; seldom for phosphor and aluminum bronzes	Common by upset or modified flash upset methods	Rec for Cu and high Cu brasses; ease with bronzes varies widely
Nickel and its Alloys	Rec for Ni, monel, Inconel; all processes	Common for Ni, monel, Inconel	Rec for most; Inconel X dfclt	Rec
Titanium	Common by inert gas	No	Common by spot and flash welding	Difficult
Lead, Zinc	Common for lead by inert gas; no for zinc	Common	Dfclt for zinc, but spot and seam used; no for lead	No
Thermoplastics	(Heated tool welding.) Rec for acrylic sheet, common for most TP sheet	(Hot gas welding.) Rec for polyethylene, PVC; common for other TP's	(Induction welding.) Common for polyethylene, acrylic; metal insert remains integral	No
Thermosets	No	No	No	No
Elastomers	No	No	No	No
Ceramics	No	Seldom	No	No
Glass	Seldom	(Blow torch.) Common	No	No
Wood	No	No	No	No
Leather	No	No	No	No
Fabric	No	No	No	No
Dissimilar Metals	Dfclt; used where melting points are within about 50 °F; galvanic action danger	Dfclt; used when melting points are within about 50° F; galvanic action danger	Dfclt; special procedures because of different thermal prop.; galvanic action danger	Ranges from dfclt to common depending on deg of dissimilarity
Metals to Nonmetallics	No	No	No	No
Dissimilar Nonmetallics	(Hot gas welding.) Dfclt; used on TP's of same basic type	(Hot gas welding.) Dfclt; used on TP's of same basic type	No	No
Dissimilar Thicknesses	Common	Common	Common	Rec

[a] Abbreviations used in the table: TP = Thermoplastic. TS = Thermosetting. Elast = Elastomeric. Rec = Recommended; easily accomplished with excellent results. Common = Commonly and widely used, though some care may be necessary. Dfclt = Difficult; special precautions, equipment, etc., necessary. Seldom = Can be done with more or less difficulty, but not common for one reason or another. No = Not used; impossible or highly specialized case if ever used.

Soldering	Adhesive Bonding (TS, TP, Elast)	Adhesive Bonding (modified compounds)	Threaded Fastening	Riveting and Metal Stitching
Seldom; graphite and high silicon content prevent bonding	Common with TS, seldom with TP	Common with epoxy 100% solids; dfclt with solvent-dispersed phenolic	Common; esp self-tapping, also integrally cast studs, hooks, etc.	Rec with large solid rivets in structural uses
Dfclt for lower carbon; seldom for higher carbon	Common with TS, seldom with TP	Common with epoxy 100% solids in paste form	Rec with all types; most fasteners made of same mtls	Rec with solid rivets for high shear, medium ten str uses
Common for 300 series with high tin solders; dfclt for 400 series	Common with TS, seldom with TP	Common with epoxy 100% solids in paste form	Rec with bolts and nuts, common with others	Common with solid stainless steel rivets for high shear str uses
Seldom; special solders available	Rec with TS, common with others, but no alkaline adh	Rec with all types	Common with self-tapping screws, inserts, others	Common with small solid aluminum rivets, or semi-tubular where low stress
Rec for copper, brass, bronze in that order	Common with TS, seldom with TP, but no natural rubber adh	Common with epoxy 100% solids as paste or film	Common with fasteners available in similar mtls	Common with small solid copper alloy rivets, seldom with semi-tubular
Common with high tin solders or others rel non-corr	Common with TS, seldom with TP	Common with epoxy 100% solids as paste or film	Rec with fasteners available in similar mtls	Common with small solid nickel alloy rivets, seldom with semi-tubular
Seldom	Seldom with TS, no TP	Common with epoxy 100% solids, heat and pressure-cured	Common; some Ti fasteners available	No
Rec with low melting solders	Rec with TS, TP, Elast in that order	Rec with all types	Rec with self-tapping screws, inserts, special fasteners	Rec with semi-tubular or split rivets, seldom with solid
No	Common with Elast for cryst types; solvent selection care nec to avoid crazing	Seldom; phenolic-Buna N most used	Seldom; inserts are used, also special fasteners	Rec with tubular rivets; stitching common (limited thk)
No	Common with TS; solvent selection care nec to avoid crazing	Common with modified epoxies on TP–TS compounds	Common with self-tapping screws, elevator bolts, inserts	Rec with semi-tubular rivets
No	Rec with phenolic, epoxy and neoprene adhesives	Common with epoxy-polysulfide, phenolic-elastomers	Seldom; inserts are used, also special fasteners	Rec with tubular or split rivets; stitching common
No	Rec with epoxy, common with other TS adhesives exc ureas	Rec with vinyl-phenolics, modified epoxies, phenolic-elastomers	Common with nuts, washers and bolts, esp load-indicating types	Seldom; semi-tubular rivets used
No	Rec with TS, common with Elast	Rec with vinyl-phenolics, phenolic-elastomers	Common with plastics fasteners, seldom with elevator bolts	Seldom; TP semi-tubular rivets used
No	Rec; phenolic for soft plywood, melamine-urea for laminations, PVC for furniture	Rec with solvent-dispersed phenolic-elastomers, latex emulsions	Rec with wood and lag screws, self-tapping screws, inserts, dowels, etc.	Common. Semi-tubular rivets for hard woods, tubular rivets for soft
No	Rec with Elast, common with TS	Rec with asphalt and latex emulsions, solvent dispersions	Seldom	Rec with tubular and split rivets, and stitching or stapling
No	Rec with Elast, polyvinyl acetate and cellulosic adh	Rec with asphalt and latex emulsions	Seldom	Rec with split rivets, stitching
Rec except where galvanic corr must be considered	Rec with TS exc solvent-dispersed types	Rec with epoxy 100% solids	Common but galvanic action may be a danger	Common although galvanic action is a danger
No	Rec. TP for shear str; TS Elast for peel str	Rec with solvent-dispersed phenolic-elastomers	Common using self-tapping screws, inserts, special fasteners	Rec with self-tapping screws, inserts, stitching
No	Rec; type varies with porosities being joined	Rec; type varies with porosities being joined	Seldom	Rec with lag screws, stitching, special fasteners
Rec	Rec where load is not peel	Rec with all types	Rec, esp bolts	Rec, esp stitching

Brazing and Soldering Alloys

Classification

Unlike welding filler metals, these alloys melt at lower temperature than the metals being joined —brazing alloys above 800 F, soldering alloys below.

Brazing Alloys. Alloys are classified by chemical composition. The two most common groups are silver alloys and copper and copper alloys. All must melt and flow freely at a lower temperature than the metals being joined, adhere to the surfaces being joined, and not oxidize or volatize too freely.

Brazing fluxes. Choice of the proper brazing flux is extremely important. Fluxes minimize oxidation, dissolve oxides that may have formed, and promote free flowing of the filler metal. A great number of proprietary fluxes are available, each with specific recommendations for use. Most of them can be classified as high temperature (above 1500 F), general-purpose low-temperature, or special purpose.

Soldering alloys. The most widely used soft solders are those composed of tin and lead, with or without other minor alloying elements. Other types include lead-silver, silver-tin-lead, bismuth-tin-lead, indium-bearing and aluminum solders.

Soldering fluxes. The most important factor in producing a sound soldered joint is the proper choice and use of a flux. The many available fluxes can be classified in two groups—corrosive and noncorrosive.

Brazing and Soldering Methods

Similar methods of heating are used for brazing and soldering. However, the furnace and salt dip methods are seldom used for soldering, and the soldering iron is not used for brazing. The most common methods use:

Soldering iron. The "iron" has a copper tip which is generally heated electrically. It is used mostly for electrical connections.

Torch. Oxyacetylene, oxyhydrogen or other gas flame torches are widely used for repair work.

Induction heating. Parts are assembled in a fixture which positions them inside an induction coil. Advantageous for large quantities of small parts.

Electric block. Similar to resistance welding with lower current. Used for small electrical parts.

Salt dip. Brazing alloy is preloaded into the work and parts are dipped into molten salt bath. Advantageous for dissimilar thicknesses and aluminum.

Metal dip. Parts are dipped in bath of molten brazing or soldering alloy. Used for irregular shapes.

Furnace. Brazing alloy is preloaded into work (usually held in jigs) which is then heated to brazing temperature in a controlled atmosphere furnace. Economical for large volumes of work.

Design Factors

Comparisons. Though brazed joints are not as strong as welded, the lower temperatures required are advantageous in that the process is faster, is performed more economically, and results in less distortion. Soldered joints are not recommended where any stress will be applied.

Joint design. Three basic types of joints are used in brazing: butt, scarf and lap. Lap joints are preferred where maximum strength is preferred. Butt joints are not recommended for soldering.

SOLDERING FLUXES

Flux ↓	Characteristics	Uses
Rosin	Noncorrosive, nonconducting, nonhygroscopic	Electrical
Tallow	Very mildly corrosive	Lead, brass, clean copper
Olive Oil or Gallipoli Oil	Very mildly corrosive	Pewter, block tin
Stearic Acid	Mildly corrosive, almost nonconductive	Electrical, lead
Aniline Phosphate or Aniline Chloride	Mildly corrosive, almost nonconductive	Electrical
Lerulinic Acid in Alcohol	Mildly corrosive, almost nonconductive	Tin cans
Lactic Acid, Phthalic Acid and Phosphoric Acid Mixed with Tallow, Resin, etc.	Mildly corrosive, slightly conductive	Electrical
Zinc Chloride	Corrosive	Iron, steel, zinc, copper, brass, bronze; terne and lead plate
Zinc Chloride and Hydrochloric Acid	Corrosive	Stainless steel, nickel, monel
Zinc Chloride and Hydrofluoric Acid	Corrosive	Brasses and bronzes containing aluminum, silicon and manganese
Orthophosphoric Acid	Corrosive	High tensile manganese bronze
Numerous Proprietary Pastes Usually Containing Zinc Chloride	Corrosive	—
Zinc Chloride and Ammonium Chloride	Corrosive	Iron, zinc, copper, brass, bronze
Dilute Hydrochloric Acid	Corrosive	Dirty zinc
Fused Salts of Zinc Chloride and Ammonium Chloride	Corrosive	Dipping method

Definitions

Eutectic. An alloy which has a melting *point* and not a *range*.

Liquidus. The lowest temperature at which the alloy is completely liquid.

Melting range. The range from the liquidus to the solidus temperature.

Solidus. The temperature at which the alloy begins to melt.

TYPICAL SOFT SOLDERS

ASTM Type ↓	Nominal Composition	Solidus, F	Liquidus, F	Spec Grav	Ten Str, 1000 psi	Applications
TIN-LEAD ALLOYS						
70A, 70B...	Sn 70, Pb 30, Sb 0.12–0.50.....	361	378	8.32	6.8	Soldering Zn-coated ferrous metals; coating metals
.....	Sn 62, Pb 38.....	361	361	—	—	General purpose; eutectic alloy
60A, 60B...	Sn 60, Pb 40, Sb 0.12–0.50.....	361	374	8.65	6.4	General purpose, esp where temp needs critical
50A, 50B...	Sn 50, Pb 50, Sb 0.12–0.50.....	361	421	8.85	5.9	General purpose; most commonly used for iron, steel, Cu alloys, Zn. Domestic plumbing
45A, 45B...	Sn 45, Pb 55, Sb 0.12–0.50.....	361	441	8.97	—	Auto radiator cores, roofing seams
40A, 40B...	Sn 40, Pb 60, Sb 0.12–0.50.....	361	460	9.3	5.8	Wiping lead pipes, cable sheaths. Auto radiator cores, galvanized iron and Zn heating units
35A, 35B...	Sn 35, Pb 65, Sb 0.25–0.50.....	361	477	9.5	—	General purpose; wiping solder
30A, 30B...	Sn 30, Pb 70, Sb 0.25–0.50.....	361	491	9.7	5.6	Machine, torch, dip, wiping methods
25A, 25B...	Sn 25, Pb 75, Sb 0.25–0.50.....	361	511	10.00	—	Machine, torch methods
20B.....	Sn 20, Pb 80, Sb 0.5.....	361	531	10.20	5.3	Joining metal parts <¼ in. thk; filling dents or seams in auto bodies; coating metals
15B.....	Sn 15, Pb 85, Sb 0.50.....	361	550	10.50	—	Joining, coating; tinning auto bodies
10B.....	Sn 10, Pb 90, Sb 0.50.....	361	570	10.80	—	Joining, coating
5A, 5B.....	Sn 5, Pb 95, Sb 0.12–0.50.....	518	594	11.30	3.4	Joining and coating, esp at high temp to 250 F
TIN-LEAD-ANTIMONY ALLOYS[a]						
.....	Sn 94, Pb 0.2, Sb 4–6.....	450	464	—	—	General purpose
40C.....	Sn 40, Pb 58, Sb 1.8–2.4.....	365	448	9.23	—	Same as 50A, 50B
35C.....	Sn 35, Pb 63.2, Sb 1.6–2.0.....	365	470	9.44	—	General purpose; wiping
30C.....	Sn 30, Pb 68.4, Sb 1.4–1.8.....	364	482	9.65	—	Torch, machine methods
25C.....	Sn 25, Pb 73.7, Sb 1.1–1.5.....	364	504	9.96	—	Same as above
20C.....	Sn 20, Pb 79, Sb 0.8–1.2.....	363	517	10.17	—	Machine soldering and coating; tipping
TIN-LEAD-INDIUM ALLOYS						
.....	Sn 37.5, Pb 37.5, In 25.0.....	274	358	—	—	Where res to strong alk soln needed (high cost)
SILVER-LEAD AND SILVER-CADMIUM ALLOYS						
2.5 S.....	Sn 0, Pb 97.5, Sb 0.40, Ag 2.3–2.7.	579	579	11.35	5.0	Cu, brass and similar metals with torch heating. Suitable for high temp but not for humid environ.
1.55.....	Sn 1, Pb 97.5, Sb 0.40, Ag 1.3–1.7.	588	588	11.28	—	Cu, brass and similar metals with torch heating. Sealing tin cans. High temp use
.....	Ag 5, Cd 95.....	640	750	—	—	High temp use
CADMIUM-ZINC AND LEAD-CADMIUM-ZINC ALLOYS						
.....	Pb 90, Cd 8, Zn 2.....	410	530	—	—	Zn and galvanized parts
.....	Cd 82.5, Zn 17.5.....	508	508	—	—	Zn-base die castings; high temp
LOW MELTING ALLOYS (BISMUTH-CONTAINING)						
.....	Bi 56, Pb 22, Sn 22.....	203	220	—	—	Special uses where low mp needed in soldering or svc
.....	Bi 67, Pb 16, Sn 17.....	203	300	—	—	Same as above
.....	Bi 40, Sn 60.....	281	338	—	—	Same as above
.....	Bi 42.5, Pb 32.7, Sn 11.3, Cd 8.5.	158	194	—	—	Same as above
.....	Bi 58, Sn 42, Zn 4.....	266	266	—	—	Same as above
ALLOYS FOR SOLDERING ALUMINUM						
.....	Sn 55–70, Zn 30–45.....	630	—	—	—	Range of special alloys for Al; also used on Mg
.....	Sn 75, Zn 25.....	401	500	—	—	Soldering capacitors to Al sheets
ALLOYS FOR SOLDERING MAGNESIUM						
.....	Sn 60, Zn 40.....	630	—	—	—	Magnesium
.....	Cd 60, Zn 30, Sn 10.....	315	—	—	—	General purpose
.....	Cd 90, Zn 10.....	500	—	—	—	Magnesium

[a] Not recommended for use on galvanized iron, cadmium or zinc parts.

continued

Brazing and Soldering Alloys—concluded

BRAZING FILLER METALS

AWS-ASTM Class ↓	Major Composition %	Available Forms	Solidus, F	Liquidus, F	Special Factors
ALUMINUM-SILICON					
BAlSi–1.....	Si 4.0–6.0, Al bal	Strip, wire, rod	1070	1165	—
BAlSi–2.....	Si 6.8–8.2, Al bal	Coated sheet	1070	1135	Only as coating on 3003, 5951
BAlSi–3.....	Si 9.3–10.7, Cu 3.3–4.7, Al bal	Strip, wire, rod	970	1085	—
BAlSi–4.....	Si 11.0–13.0, Al bal	Wire	1070	1080	Highly corr res
COPPER-PHOSPHORUS					
BCuP–1.....	P 4.75–5.25, Cu bal	Strip, wire	1305	1650	More ductile than others; less fluid
BCuP–2.....	P 6.75–7.50, Cu bal	Rod	1305	1485	Very fluid
BCuP–3.....	P 6.00–6.50, Ag 4.75–5.25, Cu bal	Wire, rod, powder	1195	1500	Very fluid
BCuP–4.....	P 6.75–7.80, Ag 5.75–6.25, Cu bal	Rod, powder	1185	1380	—
BCuP–5.....	P 4.75–5.25, Ag 14.50–15.50, Cu bal	Strip, wire, rod, powder	1185	1500	Suitable where close fits cannot be held
SILVER					
BAg–1.....	Ag 44–46, Cu 14–16, Zn 14–18, Cd 23–25	↑	1125	1145	Free flowing, narrow melting range
BAg–2.....	Ag 34–36, Cu 25–27, Zn 19–23, Cd 17–19		1125	1295	Free flowing, broader melting range than above
BAg–3.....	Ag 49–51, Cu 14.5–16.5, Zn 13.5–17.5, Cd 15–17, Ni 2.5–3.5		1195	1270	Good wetting action on carbide; wide melting range; good corr res
BAg–4.....	Ag 39–41, Cu 29–31, Zn 26–30, Ni 1.5–2.5		1240	1435	Same as above, but freer flowing
BAg–5.....	Ag 44–46, Cu 29–31, Zn 23–27		1250	1370	Wets, flows well; malleable, ductile
		Strip, wire, rod, powder			
BAg–6.....	Ag 49–51, Cu 33–35, Zn 14–18		1270	1425	Same as above; low elec res, high ductility
BAg–7.....	Ag 55–57, Cu 21–23, Zn 15–19, Sn 4.5–5.5		1145	1205	Less stress corr cracking on stainless, some Ni alloys
BAg–8.....	Ag 71–73, Cu 27–29		1435	1435	Free flowing except on ferrous metals
BAg–9.....	Ag 64–66, Cu 19–21, Zn 13–17		1280	1325	—
BAg–10.....	Ag 69–71, Cu 19–21, Zn 8–12		1335	1390	—
BAg–11.....	Ag 74–76, Cu 21–23, Zn 2.5–3.5	↓	1365	1450	—
COPPER-GOLD					
BCuAu–1....	Au 37.25–37.75, Cu bal	Strip, wire	1775	1815	[f]
BCuAu–2....	Au 79.75–80.25, Cu bal	Strip, wire	1620	1630	[f]
COPPER					
BCu.....	Cu 99.90 min	Strip, wire, rod	1980	1980	Free flowing
COPPER-ZINC					
BCuZn–1....	Cu 58.0–62.0, Zn bal	Strip, wire, rod	1650	1660	Free flowing; mod str
BCuZn–2....	Cu 57.0 min, Sn 1.0, Zn bal	Strip, wire, rod	1630	1650	Free flowing; higher str than above
BCuZn–3....	Cu 56.0 min, Sn 1.10, Mn 1.0, Ni 1.0, Zn bal	Strip, wire, rod	1590	1630	Used for capillary brazing
BCuZn–4....	Cu 50.0–55.0, Zn bal	Grain	1570	1595	Low mp; somewhat brittle
BCuZn–5....	Cu 50.0–53.0, Sn 3.0–4.5, Zn bal	Grain	1585	1610	Used for capillary brazing
BCuZn–6....	Cu 46.0–50.0, Ni 9.0–11.0, Zn bal	Strip, wire, rod	1690	1715	Generally used to make V fillet
BCuZn–7....	Cu 46.0–48.0, Ni 10.0–11.0, Ag 0.30–1.0, Zn bal	Strip, wire, rod, powder	1685	1710	High mp; good color match
MAGNESIUM					
BMg.....	Al 8.3–9.7, Zn 1.7–2.3, Mg bal	Wire, rod	770	1110	Good corr res; high str, ductility
HEAT RESISTING MATERIALS					
BNiCr.....	Ni 65–75, Cr 13–20, B 2.75–4.75[k]	Strip, wire, powder	1850	1950	Retains prop. to 2000 F
BAgMn.....	Ag 84–86, Mn 14–16	Strip, wire, rod	1760	1780	Good str at 500–900 F

[a] Immersion in 10% sulfuric acid restores copper color.
[b] BCuP–1: particularly resistance, and some furnace brazing.
[c] Lap and tee; strong, ductile joint; shear strength 20–30,000 psi.
[d] BAg–7 particularly for furnace brazing.
[e] All ferrous and nonferrous metals except Al, Mg, Ti and other metals melting below 1500 F. BAg–9, 10, 11 are used together for step brazing.

Brazing Methods	Brazing Temp Range, F	Flux	Nature of Joint	Color of Braze	Uses
Furnace, dip	1150–1185	↑	Lap. Clearance <0.010 in.	Gray	Wrought Al alloys: 1100, 3003,
Furnace	1120–1140		for laps <¼ in. long;	Gray	3004, 5050, 6951, 6053, 6061,
Furnace, dip	1060–1185	Essential	but >0.025 in. for longer	Gray	6062, 6063. Cast Al alloys:
Torch	1090–1185	↓	laps	Gray	A612, C612
↑	1450–1700	↑	Clearance: 0.002–0.005 in.[c]	Lt Gray[a]	Cu, Cu alloys; limited use for Ag,
	1350–1550	Self-fluxing on	Clearance: 0.001–0.003 in.[c]	Lt Gray	W, Mo. Do not use on ferrous
All methods[b]	1300–1550	copper; flux rec on	Clearance: 0.002–0.005 in.[c]	Lt Gray	alloys containing more than 10%
	1300–1500	other metals	Clearance: 0.001–0.003 in.[c]	Lt Gray	Ni. Not rec for sulfurous atm
↓	1300–1500	↓	Clearance: 0.003–0.005 in.[c]	Lt Gray	above room temp
↑	1145–1400	↑	↑	Lt Yellow	Unstabilized types of stainless[e]
	1295–1550			Lt yellow	Where tolerances cannot be as closely controlled[e]
	1270–1500			Whitish yellow	Joining carbide tool tips to tool shanks[e]
	1435–1650		Lap rec; butt sometimes	Lt yellow	Carbide tip brazing[e]
	1370–1550	Required unless	used. Clearances 0.002–	Lt yellow	Elec equip.; food and dairy equip.
		brazing is done in	0.005 in. Fatigue str about		where Cd-containing alloys
All methods[d]		vacuum or inert	that of metals being joined		might be prohibited[e]
	1425–1600	atm	(to 27,000 psi). Tough,	Lt yellow	Same as above
	1205–1400		ductile, high impact str;	Whitish	Food and dairy equip.[e]
			ten str, 50–60,000 psi		
	1435–1650			White	Assembling electronic tubes[e]
	1325–1550			Whitish	Particularly with sterling silver[e, f]
	1390–1600			Whitish	Same as above
↓	1450–1650	↓	↓	Whitish	Same as above
Induction, furnace, resistance	1815–2000	None[g]	—	Copperish	Special alloy for joining parts in electron tube assemblies
Same as above	1630–1850	None[g]	—	Copperish	Same as above
Furnace[h]	2000–2100	None[i]	Clearance: 0.000–0.002 in.[j]	Yellow	Ferrous metals; Ni and Cu-Ni alloys
Torch, furnace, induction	1670–1750	↑	↑	Yellow	Steels, Ni and Cu alloys
"	1670–1750			Yellow	Same as above
"	1670–1750			Yellow	Same as above
		Required; borax-	Lap, butt; clearances 0.002–		
"	1600–1700	boric acid com-	0.005 in. High str in shear	Pale yellow	Steels, Ni alloys
"	1620–1700	monly used	and tension	Grayish yellow	Same as above
All methods	1720–1800			Gray	Same as above
All methods	1690–1800	↓	↓	Gray	Same as above
Torch, furnace, dip; sometimes others except resistance	1120–1160	Req; fluxes contain KCl, NaCl, some fluorides	Lap; clearances 0.004–0.010 in.	Gray	Mg alloy M1A
Furnace, generally using controlled dry H_2 atm	2000–2150	None in red. atm; otherwise necessary	Variable	Gray	Stainless steels, high Ni alloys; jet engines
Same as above	1780–2100	Same as above	Variable	Gray	Stainless steels, high Ni alloys; lower temp than BNiCr

[f] Variation in brazing temp permits step brazing.
[h] Using H_2 or dissociated ammonia atmosphere.
[j] Otherwise same nature as CuZn alloys.
[g] In reducing atmosphere or vacuum; otherwise borax-boric acid flux.
[i] Except on metals with oxide constituents.
[k] Total Fe + Si + C = 10% max.

Welding Electrodes and Rods

Classification

Welding rods and electrodes are generally grouped broadly according to the major metal (or metals) of which they are composed. Some are also grouped by the metals which they are used to weld. (These two classifications are often identical because it is usually desirable to weld base metals with a filler metal of similar composition.) A few groups of rods and electrodes are also defined by the welding method with which they are used.

Each broad group of rods and electrodes is further classified according to one or more of the following factors: chemical composition; coating, current and welding position; mechanical properties; appearance

EXPLANATION OF AWS-ASTM ROD AND ELECTRODE CLASSIFICATION NUMBERS
(And Key to the Charts in This Welding Section)

Electrode or Rod Group ↓	AWS-ASTM Spec	Sample Class No.[a]	Type of Specified Conditions Indicated by Class No.[b]	See Table No. . . .
WELDING IRONS AND STEELS				
Mild Steel (coated and covered)	A233–55T	E6010	60—properties; 10—manner of use[c]	2a, 2b
Low Alloy Steel (covered)	A316–54T	E7010[e]	70—properties; 10—manner of use	2a, 2b
		E7010–A1[e]	70—properties; 10—modifies comp; A1—comp of weld	2a, 2c
Stainless Steel (covered)	A251–46T	E308ELC–15	308—comp of weld; ELC—modifies comp; 15—manner of use. Properties are also specified[d]	3
Stainless Steel (bare)[f]	A371–53T	ER308L	308—comp as mfd; L—modifies comp	3
For Welding Cast Iron[g]	A398–56T	RCuAl–A2	CuAl—comp as mfd; A2—modifies comp. Visual examination of weld is also specified[d]	4
For Gas Welding Irons and Steels	A251–46T	GA65	A65—properties	5
WELDING NONFERROUS METALS				
Copper and Copper Alloy	B225–53T (electrodes)	ECuAl–A2	CuAl—comp as mfd; A2—modifies comp. Properties are also specified[d]	6
	B259–52T (rods)	RCuAl–A2	CuAl—comp as mfd; A2—modifies comp	6
Nickel and Nickel Alloy	B295–54T (covered electrodes)	E3N10[h]	3—base metal; 1—welding method; 0—comp of core as mfd. Comp of weld, tensile strength are also specified[d]	7
	B304–56T (bare electrodes and rods)	ERN6(\	6—welding method; 0—comp as mfd	8
Aluminum and Aluminum Alloy	B184–43T (covered electrodes)	Al–2	2—comp of core as mfd	9
	B285–54T (bare electrodes and rods)	R–CN42A[i]	CN42—comp as mfd	9
Magnesium and Magnesium Alloy[f]	No specifications; alloys can be joined by gas welding and inert-gas shielded arc processes. In general, filler metal should have same composition as alloy being joined			
Lead and Zinc	No specifications; gas welding most commonly used. In general, filler metal should have same composition as alloy being joined			

[a] The first letter of the designation is either "E" for electrode or "R" for rod.
[b] The figures used are samples, e.g., the "10" for mild steels may be 11, 12, etc., each indicating a different manner of use. Properties = Mechanical properties of the deposited weld metal. (The figures approximate the minimum tensile strength in units of 1000 psi.) Manner of use = Type of current, polarity (if d.c.), welding position, type of covering.
[c] These figures also indicate a modification in minimum mechanical properties specified.
[d] Specified, but not represented in the classification number.
[e] Must be classified one way or the other, not both.
[f] Used as both rods and bare electrodes. As rods—atomic hydrogen and inert-gas metal arc (nonconsumable electrode) welding. As bare electrodes—submerged arc and inert-gas metal-arc (consumable electrode) welding.
[g] Includes rods for oxyacetylene and carbon arc welding, covered electrodes for shielded metal arc welding. Types included here are: cast iron, copper-base, nickel-base and mild steel.
[h] The "N" designates "nickel."
[i] The "A" designates "aluminum."

1—TYPICAL PROPERTIES OF MILD STEEL ARC WELDED DEPOSITS

AWS—ASTM Class ↓	Ten Str, 1000 psi	Yld Point, 1000 psi	Elong (in 2 in.), %	Red. of Area, %	Impact Str, ft-lb[a]	Endur Limit, 1000 psi	Brinell Hardness
E4510	45	Not spec	5	—	—	—	—
E4520	45	Not spec	5	—	—	—	—
E6010	62–65	52–58	22–28	35	30–40, 20–30	28–32	140–160
E6011	62–73	52–61	22–28	35	30–40, 20–30	28–32	140–160
E6012	68–78	55–65	17–22	25	20–30, 15–20[b]	—	150–170
E6013	68–78	55–65	17–22	25	—	—	150–170
E6015	68–76	55–62	22–35	55–75	35–45, 30–40	—	140–160
E6016	68–76	55–62	22–35	55–75	35–45, 30–40	—	140–160
E6020	62–68	52–58	25–30	40	20–30, 15–20	30–34	150–170
E6024	77–87	65–75	17–22	30–45	20–35, 15–20	—	150–170
E6027	62–68	52–58	25–30	40	25–35, 20–30	30–34	150–170
E6030	62–68	52–58	25–30	40	20–30, 15–20	30–34	150–170

[a] Charpy keyhole. First value is at 70 F, second at −40 F, unless otherwise specified. [b] At 0 F.

of the weld; intended end use. The key chart on the opposite page indicates the method of classifying each group according to American Welding Society specifications.

In some cases there is a choice offered by the specification; the manufacturer may be allowed to select one of several classification methods, or may be allowed to list an electrode by more than one classification.

The numbered charts on this and the following six pages classify the rods and electrodes within each group by the applicable method and also give other information, such as method of use, typical properties and some common applications.

Welding Processes

Arc welding. A group of processes wherein coalescence is produced by heating with an electric arc. The metal to be welded is one pole of an electric circuit and the electrode is the other pole. A suitable gap forms a heat generating arc. (The metal participates in the production of heat but is not the sole source.) Carbon or metal electrodes may be used. If covered metal electrodes are used the process is referred to as *shielded.* There are other methods of shielding, such as using an inert gas (helium or argon), or a blanket of granular, fusible material on the work (referred to as *submerged arc welding*).

Braze welding. Uses a brazing torch but is classified technically as a welding process because the filler metal is distributed by gravity and not, as in brazing, by capillary action.

Gas welding. A group of processes wherein coalescence is produced by heating with a gas flame, most commonly obtained by the combustion of acetylene with oxygen (*oxyacetylene welding*).

Resistance welding. A group of processes wherein coalescence is produced by the heat generated from resistance to flow of electric current through the work, and by pressure. Heat is generated in two places: in the body of the work where only the resistivity of the material determines the amount of heat; and at contact surfaces where resistivity is affected by pressure, surface oxides and compounds, and surface roughness and cleanliness. No fluxes or filler metals are used. Various types of resistance welding processes are named according to the method of determining pressure points. Examples are: *spot welding* (two welding tips pressing the work together in one spot at a time); and *projection welding* (welding dies are used and pressure points determined by projections designed as an integral part of the work). Other processes are named according to the speed of effecting contact and pressure and their timing with reference to the heating cycle (*flash* and *upset*).

Definitions

Filler metal. A broad term for the metal added in making a weld. It may or may not carry electric current.

Rod. Filler metal, in wire or rod form, which does not carry current. Rods are used in gas welding or in arc welding with a separate carbon or tungsten electrode.

Electrode. The current-carrying element. With three exceptions, it is also the filler metal. Carbon and tungsten electrodes are not filler metals. The third exception is the "resistance welding electrode," a term applied to the part of the resistance welding machine that transmits current (and usually pressure) to the work. A resistance welding electrode may be in the form of a wheel, bar, cylinder, clamp, etc.

Bare, lightly coated, covered. Terms which apply to filler metals (either rods or electrodes) used in arc welding. However, since rods are usually bare, the terms are generally reserved for filler metal electrodes. The purpose of a light coating is primarily to stabilize the arc. "Covered" wires have a relatively thick coating which protects the molten metal from the atmosphere, improves weld metal properties, and stabilizes the arc.

continued
text continued on p 382

Welding Electrodes and Rods—continued

2a—MILD AND LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Current, Welding Position and Covering)

AWS-ASTM Class ↓	Current, Polarity	Welding Position[a]	Covering	Properties Not Specified By ASTM Class: Deposit Appearance	Slag[b]	Deposition Rate	Arc Characteristics
Exx10[c]	D.c. reversed	F, V, OH, H	High cellulose sodium	Flat, rippled	Thin	Slow	Spray, deep penetration
Exx11	A.c. or d.c. reversed	F, V, OH, H	High cellulose potassium	Flat, rippled	Thin	Slow	Spray, deep penetration
E6012	A.c. or d.c.	F, V, OH, H	High titania sodium	Convex, rippled	Dense	Medium	Globule, medium penetration
Exx13	A.c. or d.c. straight	F, V, OH, H	High titania potassium	Concave, slightly rippled	Medium	Med fast	Globule, shallow penetration
Exx15	D.c. reversed	F, V, OH, H	Low hydrogen sodium	Flat, convex	Heavy	Medium	Globule, medium penetration
Exx16	A.c. or d.c. reversed	F, V, OH, H	Low hydrogen potassium	Flat, convex	Heavy	Medium	Globule, medium penetration
Exx20[a]	Horiz fillets—a.c. or d.c. straight; flat—a.c. or d.c. either polarity	H fillets, F	High iron oxide	Concave, smooth	Heavy	Fast	Spray, medium penetration
E6024	A.c. or d.c. either polarity	H fillets, F	Iron powder, titania	Convex, smooth	Heavy	Fast	Smooth, quiet, shallow penetration
E6027	Horiz fillets—a.c. or d.c. straight; flat—a.c. or d.c. either polarity	H fillets, F	Iron powder, iron oxide	Flat, concave, smoothly rippled	Heavy	Fast	Spray, medium penetration
E6030	A.c. or d.c. either polarity	F	High iron oxide	Flat, concave, smoothly rippled	Dense	Fast	Spray, deep penetration

[a] F = flat, V = vertical, OH = overhead, H = horizontal.
[b] All slag deposits are readily removable except E6012 which is rated "fair."
[c] When xx = 45, the only column in this table that applies is "Welding Position." Current and polarity of 4510 and 4520 are not specified, but generally d.c. straight polarity is used. These two electrodes are not covered but are either sulcoated or light coated.

2b—MILD AND LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Minimum Mechanical Properties)[a]

AWS-ASTM Class ↓	Ten Str, 1000 psi	Yld Point, 1000 psi	Elong (in 2 in.), %
MILD ALLOY STEEL ELECTRODES			
4510, 4520	45	Not spec	5
6010, 6011	62	50	22
6012, 6013, 6024	67	55	17
6015, 6016	67	55	22
6020, 6027, 6030	62	50	25
LOW ALLOY STEEL ELECTRODES			
70xx	70	57	22[b]
80xx	80	67	19[c]
90xx	90	77	17[d]
100xx	100	87	16[e]
120xx	120	107	14

[a] Classification by mechanical properties is represented by the first two digits. For low alloy steel electrodes the digits are exactly the minimum tensile strength in units of 1000 psi. For mild alloy steel the digits are approximately the minimum tensile strength in 1000 psi units.
[b] Elongation is 25% for 7020.
[c] Elongation is 16% for 8013.
[d] Elongation is 14% for 9013.
[e] Elongation is 13% for 10013.

2c—LOW ALLOY STEEL COVERED ELECTRODES
(Classified by Chemical Composition of Weld)[a]

↓ AWS-ASTM Class	
CARBON-MOLYBDENUM STEEL	
A1	C 0.10, Mo 0.40–0.65
CHROMIUM-MOLYBDENUM STEEL	
B1	C 0.10, Cr 0.40–0.65, Mo 0.40–0.65
B2	C 0.10, Cr 1.00–1.50, Mo 0.40–0.65
B3	C 0.12, Cr 2.00–2.50, Mo 0.90–1.20
NICKEL STEEL	
C1	C 0.12, Ni 2.00–2.75
C2	C 0.10, Ni 3.00–3.75

[a] Classification of low alloy steel electrodes by chemical composition can be found in AWS–ASTM specification A316–54T. Compositions are represented by a letter and a number following the standard classification, but the percentages of certain minor elements are modified by the second two digits. This table gives only the percentages of the major elements.

3—STAINLESS STEEL RODS AND ELECTRODES

Covered Electrodes		Rods and Bare Electrodes		Applications	Min Mechanical Properties of Covered Electrode Deposits	
AWS-ASTM Class[a] ↓	Major Composition of Weld Metal, %[b]	AWS-ASTM Class[c] ↓	Major Composition As Manufactured, %[b]		Ten Str, 1000 psi	Elong (in 2 in.), %
E308.....	C 0.08, Cr 18.0–21.0, Ni 9.0–11.0	ER308....	C 0.08, Cr 19.5–22.0, Ni 9.0–11.0	Weld base metal of similar composition	80	35
E308ELC ..	C 0.04, Cr 18.0–21.0, Ni 9.0–11.0	ER308L...	C 0.03, Cr 19.5–22.0, Ni 9.0–11.0	Low C reduces carbide precipitation, avoiding intergranular corrosion without need for stabilizers	75	35
E309.....	C 0.15, Cr 22.0–25.0, Ni 12.0–14.0	ER309....	C 0.12, Cr 23.0–25.0, Ni 12.0–14.0	Weld similar alloys, wrought or cast. Weld 18–8 for severe corrosion conditions	80	35
309Cb.....	C 0.12, Cr 22.0–25.0, Ni 12.0–14.0, Cb+Ta 0.70–1.00	.....	.....	Primarily weld type 347 clad steel or dissimilar metals. Cb stabilizes against intergranular corrosion, provides high strength at high temperatures	80	30
E309Mo...	C 0.12, Cr 22.0–25.0, Ni 12.0–14.0, Mo 2.00–3.00	.....	.....	Primarily weld type 316 clad steels or dissimilar metals (similar to E309 with Mo added, C reduced)	80	35
E310.....	C 0.20, Cr 25.0–28.0, Ni 20.0–22.0	ER310....	C 0.08–0.15, Cr 25.0,[d] Ni 20.0[d]	High strength, ductility useful in welding such hardenable steels as armor plate. Also weld clad steels	80	30
E310Cb....	C 0.12, Cr 25.0–28.0, Ni 20.0–22.0, Cb+Ta 0.70–1.00	.....	.....	Same uses as E309Cb	80	25
E310Mo...	C 0.12, Cr 25.0–28.0, Ni 20.0–22.0, Mo 2.00–3.00	.....	.....	Same uses as E309Mo	80	30
E312.....	C 0.15, Cr 26.0–31.0, Ni 8.5–10.5	.....	.....	Primarily weld cast alloys of similar composition. A recent use: weld dissimilar metals when one is high in nickel	95	22
E316.....	C 0.08, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50	ER316....	C 0.08, Cr 18.0–20.0, Ni 12.0–14.0, Mo 2.0–2.5	Weld similar alloys containing 2 to 3% Mo. Molybdenum content provides creep resistance at high temperatures	80	30
E316ELC ..	C 0.04, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50	ER316L...	C 0.03, Cr 18.0–20.0, Ni 12.0–14.0, Mo 2.0–2.5	Primarily weld extra low carbon, molybdenum-bearing austenitic alloys	75	30
E317.....	C 0.08, Cr 18.0–21.0, Ni 12.0–14.0, Mo 3.00–4.00	ER317....	C 0.08, Cr 18.5–20.5, Ni 13.0–15.0, Mo 3.25–4.0	Weld similar alloys that must meet severe corrosion requirements involving sulfuric and sulfurous acids, salts	80	30
E318.....	C 0.08, Cr 17.0–20.0, Ni 11.0–14.0, Mo 2.00–2.50, Cb+Ta 1.00[e]	.....	.....	Primarily weld metals of similar composition (identical to E316 with Cb added)	80	25
E330.....	C 0.25, Cr 14.0–17.0, Ni 33.0 min	ER330....	C 0.15–0.25, Cr 15.0–17.0, Ni 34.0[d]	Repair defects in alloy castings; weld similar alloys. Nickel content gives heat and scale resistance above 1800 F	75	25
E347.....	C 0.18, Cr 18.0–21.0, Ni 9.0–11.0, Cb+Ta 1.00[f]	ER347....	C 0.08, Cr 18.5–21.0, Ni 8.5–10.5, Cb+Ta 1.00[g]	Usually weld Cr-Ni alloys of similar composition stabilized with Cb or Ti	80	30
E410.....	C 0.12, Cr 11.0–14.0, Ni 0.60	ER410....	C 0.07–0.12, Cr 12.0–14.0, Ni 0.6, Mo 0.6	Weld similar alloys; deposit overlays on carbon steels for corrosion, erosion and abrasion resistance. Air-hardening, it requires preheat and post-heat treatment to obtain ductility	70	20
.....	.....	ER420....	C 0.25–0.40, Cr 12.0–14.0, Ni 0.6	Similar to E410, but better resistance to corrosion, abrasion	—	—
E430.....	C 0.10, Cr 15.0–18.0, Ni 0.60	ER430....	C 0.10, Cr 15.5–17.0, Ni 0.6	Similar to E410. Cr limit gives adequate corrosion resistance, yet retains ductility	70	20
E502.....	C 0.10, Cr 4.0–6.0, Ni 0.40, Mo 0.45–0.65	ER502....	C 0.10, Cr 4.5–6.0, Ni 0.4, Mo 0.45–0.65	Weld similar metals, usually pipe or tubing	60	20

[a] The complete classification numbers are *Exxx–15* or *Exxx–16*. The *–15* suffix indicates a lime covering, *–16* a lime or titania covering. Polarity and welding position requirements are the same as those listed in chart 2 for Exx–15 and Exx–16.
[b] Maximum percentages unless otherwise specified. Carbon analysis required to nearest 0.01%.
[c] For consumable electrode welding, d.c. reversed polarity is preferred.
[d] Minimum. [e] Minimum is 6 x C. [f] Minimum is 8 x C. [g] Minimum is 10 x C.

continued

Welding Electrodes and Rods—continued

4—RODS AND ELECTRODES FOR WELDING CAST IRON

AWS-ASTM Class [a] ↓	Common Name[b]	Welding Method	Remarks	Uses
RCI.....	Cast iron	Oxyacetylene	Produces machinable deposit of same color, composition and structure as base metal	Fill in or build up new or worn gray iron castings. General fabrication, salvage, repair
ECI.....	Cast iron	Arc; a.c. or d.c. reversed polarity	Basically RCI with heavy covering. Weld metal flows readily; light slag easily removable	Weld and repair gray iron castings; faster than oxyacetylene for repairing small defects
RCI-A	Alloy cast iron	Oxyacetylene	Similar to RCI but higher melting. Weld metal more fluid; welding more rapid	Gray or alloy cast iron to obtain greater tensile strength and finer grain structure than RCI
RCuZn-A[c].....	Naval brass	Oxyacetylene	Better strength, corr res than basic 60 Cu-40% Zn alloy. Deposits 70–90 Bhn	Where color match is not required and weldments are not subject to electrolytic corrosion or high temperature service
RCuZn-B[c].....	Manganese bronze	Oxyacetylene	Better strength, hardness, corr res than 60 Cu-40% Zn alloy. Deposits 80–110 Bhn	Same as above
RCuZn-C[c].....	Low-fuming bronze	Oxyacetylene	Diminishes zinc oxidation (fuming). Slightly higher mechanical properties than naval brass or manganese bronze; deposits 80–110 Bhn	Same as above
RCuZn-D[c].....	Nickel bronze	Oxyacetylene	Color is silver rather than yellow. Low fuming. Deposits 90–110 Bhn	Same as above
ECuAl-A2[d], RCuAl-A2[c]	Aluminum bronze (9–11 Al, 1.5% Fe)	Electrodes—arc welding; a.c. and d.c. reversed polarity. Rods—carbon arc welding	Low m.p. permits rapid welding to minimize distortion. Yld and ten str twice those of ECuSn alloys (below)	Weld the new higher strength cast irons. Overlay corrosion and wear resistant surfaces
ECuSn-A[d].....	Phosphor bronze (4.8–5.8% Sn)	Arc; d.c. reversed polarity	Deposits 70–85 Bhn	Weld cast iron and overlay bearing and corrosion resistant surfaces
ECuSn-C[d].....	Phosphor bronze (7.0–9.0% Sn)	Same as above	Deposits 85–100 Bhn. Higher yld and ten str than ECuSn-A	Same as above
ENi.....	Nickel	Arc; flat specified but other positions have been used	Rapid, widely used. Even without preheating, deposits can be machined	Weld ordinary gray irons to themselves or to other ferrous and nonferrous materials; light and medium-sized castings. Reclamation and repair
ENiFe.....	Nickel-iron	Same as above	Same as above, but higher ten str and ductility	Weld various cast irons to steel and other ferrous and nonferrous materials; heavy and highly stressed sections. Better than ENiFe for castings containing more than 0.20% P
ENiCu-A.....	Nickel-copper (55–60% Ni)	Same as above	Similar to ENiFe	Similar to ENiFe
ENiCu-B.....	Nickel-copper (63–70% Ni)	Same as above	Similar to ENi	Similar to ENi
ESt.....	Mild steel	Arc; a.c. or d.c. reversed polarity	Designated specifically for cast iron; has a low m.p. Covering and deposits not readily machinable	Largely confined to repair of small pits and cracks in cast iron; some larger repairs if casting requires no machining

[a] Chemical symbols for the major elements of the composition are used to classify these rods and electrodes. In other cases, CI = cast iron and St = steel. The letter, or letter and number, following the hyphen indicates a modification of a standard composition.
[b] For exact chemical composition as manufactured, see ASTM A398–56T.
[c] Also a standard classification under Copper and Copper Alloy Welding Rods.
[d] Also a standard classification under Copper and Copper Alloy Welding Electrodes.

Other welding processes. Each process has variants not described and less commonly used. There are also special processes such as *flow welding*, *forge welding*, *thermit welding* and *induction welding*. All of these are described in detail in the *Welding Handbook* of the American Welding Society.

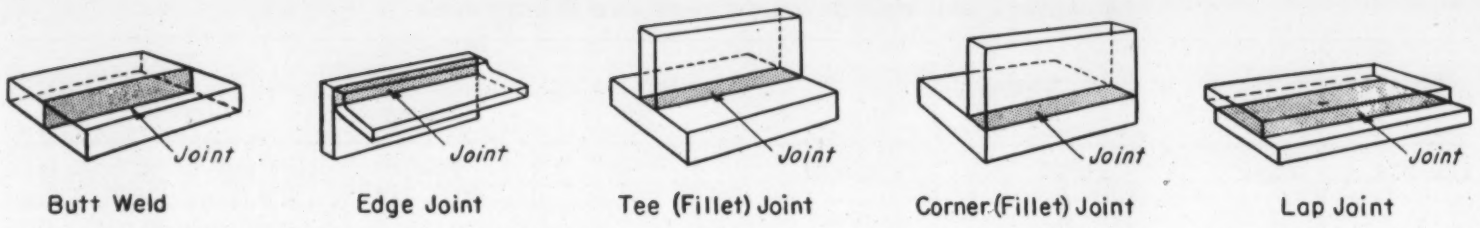


Fig 1—*The five basic welding joint designs.*

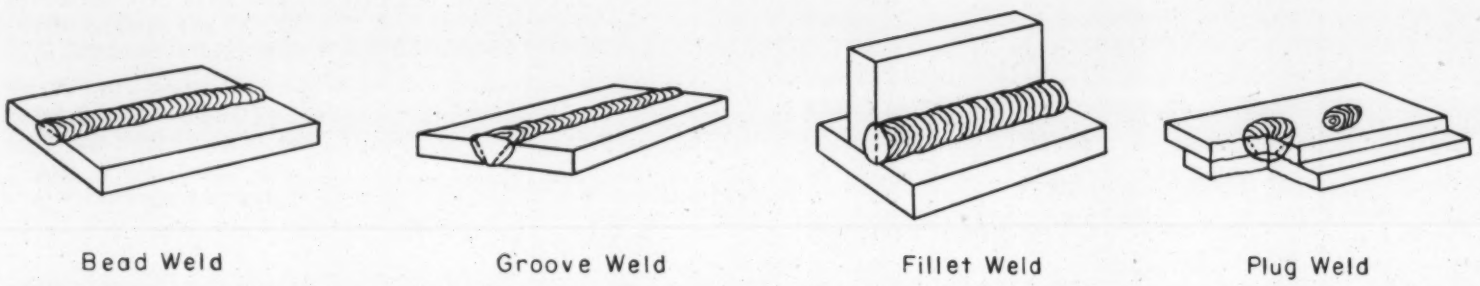


Fig 2—*The four basic weld types for arc and gas welding.*

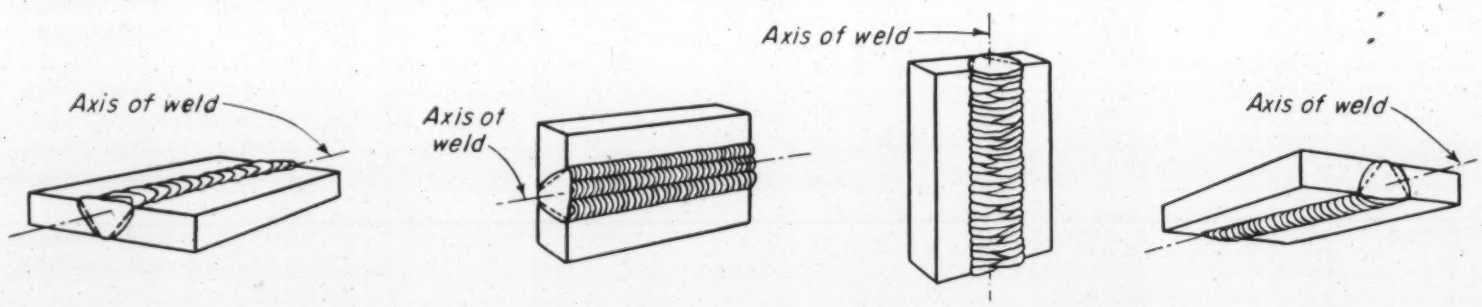


Fig 3—*The four basic welding positions.*

5—RODS FOR GAS WELDING IRONS AND STEELS [a]

AWS-ASTM Class ↓	Weld Treatment[b]	Min Ten Str, 1000 psi	Min Elong (in 2 in.), %
GA65	SR	65	20
	NSR	72	17
GA60	SR	60	25
	NSR	62	20
GA50	SR	50	28
	NSR	52	23
GB65	SR	65	18
	NSR	72	15
GB60	SR	60	20
	NSR	62	15
GB45	NSR	45	—

[a] Mechanical tests are performed on welds made by either 5/16- or 1/4-in. rods and on plates 3/4 in. thick (except GB45 which requires a 3/8-in. plate).
[b] SR = stress relieved; NSR = non-stress relieved

Design Factors

Welding is a basic production method whose end product is a metal part or form termed a "weldment." Weldments must be considered in competition with castings, forgings and other fabricated forms, as well as other joining methods.

Sizes and shapes. A wide range of thicknesses, sizes and shapes can be joined by welding. Parts as thin as 1 mil and as thick as 20 in. have been welded commercially. Plate and sheet stock are the most widely used forms, but forgings, castings, extrusions and rolled shapes are also used in fabricating weldments.

Tolerances. The two principal factors influencing tolerances are distortion from the welding operation and the tolerances of the metal forms that make up the weldment. The tolerances on the various metal forms, such as flat stock, castings, forgings and rolled sections, are easily obtainable. But degree of welding distortion is a function of a great many things, and exact values cannot be given. The following tolerances seem to be those most commonly achieved:

1. Small parts containing very little welding, 1/8 in.
2. Moderately large parts containing a small amount of welding, 1/4 in.
3. Large structures containing moderate amounts of welding, 3/8 in.
4. Large, complicated structures, and structures containing large amounts of welding, 3/8 to 1/2 in.

continued

Welding Electrodes and Rods—concluded

6—COPPER AND COPPER ALLOY RODS AND ELECTRODES

AWS-ASTM Class ↓	Common Name	Welding Method[a]	Current, Polarity	Min Ten Str, 1000 psi	Brinell Hardness	Applications
ECu, RCu....	Copper	IGMA (E, R), CA (R), OG (R)	D.c. straight	25	25–40[b]	Light gage Cu up to 3/16 in.—R[c]; heavier gage—E. Deoxidized Cu (R)[e, f]
ECuSi, RCuSi-A....	Silicon bronze (Si 2.8–4.0%)	IGMA (E, R), SMA (E), CA (R), OG (R)	D.c. reverse (E), d.c. straight (R)	50	80–100	Primarily for welding Cu, CuSi and CuZn to themselves (E, R) and to steel (R)[e, f]. Mtl over 1/16 in. thk (E).[d] Silicon bronze; overlay for corr res (E)[g]. CuSi alloys (R)[e]
RCuSi-B.....	Silicon bronze (Si 1.02–2.0%)	CA, OG	D.c. straight	35	60–85	Red brass piping[e]. Cu, CuSi and CuZn[f]; Cu to steel[f]; galvanized iron[f]
RCuSn.....	Phosphor bronze (Sn 4.0–6.0%)	CA, IGMA-NC	D.c. straight	35	70–85	Cu[e, f] and CuSn[e]
ECuSn-A[i]....	Phosphor bronze (Sn 4.8–5.8%)	SMA, IGMA-C	D.c. reverse	35	70–85	Weld phosphor bronzes of similar comp. "A" and "C" (below) used interchangeably for Cu, brasses, bronzes, cast iron, dissimilar metals
ECuSn-C[i]....	Phosphor bronze (Sn 7.0–9.0%)	SMA, IGMA-C	D.c. reverse	40	85–100	Same as above, but "C" provides higher ten and yld str, higher hardness
ECuNi, RCuNi	Copper nickel	SMA (E), OG (R), IGMA-NC(R)	D.c. reverse (E), d.c. straight (R), a.c. (R)	50	60–80	CuNi alloys (10–30%) to themselves to provide good corr res
RCuZn-A[i]....	Naval brass	BW, OG	—	50	70–90	Brass[e]. Cu, bronze, Ni alloys, steel, cast and malleable iron[h]
RCuZn-B[i]....	Manganese bronze	BW	—	55	80–110	Steel and cast iron[h]. As surfacing filler metal for building up bearings
RCuZN-C[i]....	Low-fuming bronze	BW, OG	—	57	80–110	General purpose
RCuZn-D[i]....	Nickel bronze	BW, OG	—	60	90–110	Steel and cast iron[h]
ECuAl-Al, RCuAl-Al...	Aluminum bronze (iron-free)	IGMA (E, R), CA (R)	D.c. reverse (E), a.c. (R)[e], d.c. straight (R)[e, f]	55	100–158 (E), 100–130 (R)[f], 100–150 (R)[e]	Annealed aluminum bronze plate, sheet and strip (E, R). Repair castings (E, R)[e, f]. Overlay bearing and corr res surfaces (E, R)[e]
ECuAl-A2[i], RCuAl-A2[i].	Aluminum bronze (Fe 3.0–4.25%)	IGMA (E, R), SMA (E), CA (R)	D.c. reverse (E)[d, g], d.c. straight (R)[e, f], a.c. (E[g], R[e])	60 (E), 65 (R)	130–150 (E)[g], 150–170 (E)[d], 100–130 (R)[d], 100–150 (R)[e]	Aluminum bronze, high str CuZn alloys, silicon bronze, nickel alloys, ferrous alloys, dissimilar metals. Repair castings; overlay bearing and corr res surfaces
ECuAl-B, RCuAl-B...	Aluminum bronze (Fe 3.0–4.25%)	SMA (E), CA (R), IGMA-NC(R)	D.c. reverse (E), d.c. straight (R)[e, d], a.c. (E, R[e])	65 (E), 70 (R)	140–180 (E), 140–180 (R)[f], 180–220 (R)[e]	Similar to above, but provides higher phys prop. Weld nonferrous metals to steel (E,R)[e]

[a] Method symbols are: IGMA = inert-gas metal arc welding (-C = consumable electrode; -NC = nonconsumable electrode); OG = oxyacetylene welding, CA = carbon arc welding, SMA = shielded metal arc welding (covered electrodes), BW = braze welding.
[b] Rockwell F.
[c] Inert-gas metal arc (nonconsumable electrode) welding.
[d] Inert-gas metal arc (consumable electrode) welding.
[e] Oxyacetylene welding.
[f] Carbon arc welding.
[g] Shielded metal arc welding (covered electrode).
[h] Braze welding.
[i] Also a standard classification under Rods and Electrodes for Welding Cast Iron.

Joint design. There are five fundamental types of arc or gas welded joints (see Fig 1) and four basic types of welds (see Fig 2), but variations of these are used to satisfy particular requirements. Resistance welding commonly employs the lap joint, although flash welding requires a butt joint.

Welding positions. Welds are classified by four basic positions; for each, certain electrodes are recommended or not recommended. The position terms—flat, vertical, horizontal and overhead—can be applied to all types of welds, but they are illustrated here for the groove weld (see Fig 3).

[a] Used with shielded metal arc welding process.
[b] These electrodes are used to join alloys of same composition as the electrode. When first digit of designation is *3*, electrode is used primarily to join similar alloys to themselves; when first digit is *4*, electrode is used to weld a nickel or nickel-base alloy to steel, to overlay a nickel or nickel-base alloy on steel, or to weld the clad side of nickel or a nickel-base alloy clad steel.
[c] Used to weld not only mill products but also castings of suitable welding quality.
[d] Also used to weld such copper-nickel alloys as 70–30, 80–20 and 90–10 to themselves.
[e] Also used for a number of dissimilar metal combinations.
[f] Age hardened.
[g] Also used to weld alloys of similar composition to steel-clad materials or other metals.

7—NICKEL AND NICKEL ALLOY COVERED ELECTRODES [a]

AWS-ASTM Class[b] ↓	Alloy	Common Name	Min Ten Str, 1000 psi
E3N10.....	Nickel-copper (C 0.40, Mn 4, Cb+Ta 0%)	Monel[c,d]	70
E3N11.....	Nickel (C 0.75)	Nickel[c]	55
E3N12.....	Nickel-chromium-iron	Inconel[c]	80
E3N14.....	Nickel-copper-aluminum	K monel[e]	100[f]
E3N19.....	Nickel-chromium-iron-titanium	Inconel X	115[f]
E3N1B, E4NiB..	Nickel-molybdenum	Hastelloy B[g]	100
E3N1C, E4NiC..	Nickel-molybdenum-chromium	Hastelloy C[g]	100
E4N10.....	Nickel-copper (C 0.15, Mn 2.50, Cb+Ta 3%)	Monel	—
E4N11.....	Nickel (C 0.10%)	Nickel	—
E4N12.....	Nickel-chromium	Inconel	—

8—NICKEL AND NICKEL ALLOY RODS AND BARE ELECTRODES

AWS-ASTM Class[a] ↓	Alloy	Common Name	Welding Method[b]
RN40.....	Nickel-copper (Mn 2, Al 0, Ti 0)	Monel	OG[c]
ERN60.....	Nickel-copper (Mn 1, Al 1.25, Ti 1.50–3.00)	Monel	IGMA, At. H_2
RN41.....	Nickel (Mn 0.35, Fe 0.40, Ni 97 min, Al 0, Ti 0.50)	Nickel	OG[c]
ERN61.....	Nickel (Mn 1, Fe 1, Ni 93 min, Al 1.50, Ti 2.00–3.50)	Nickel	IGMA, At. H_2
RN42.....	Nickel-chromium-iron (Ni 72 min, Cb+Ta 0)	Inconel	OG, IGMA[d]
ERN62.....	Nickel-chromium-iron (Ni 70 min, Cb+Ta 1.50–3.00)	Inconel	IGMA, At. H_2, OG
RN43.....	Nickel-copper-silicon	—	OG[e]
ERN64.....	Nickel-copper-aluminum	K Monel	IGMA, At. H_2[f]
ERN69.....	Nickel-chromium-iron-titanium	Inconel X[g]	IGMA, At. H_2[f]
ERN6N.....	Nickel-chromium-titanium	Nimonic 7s	IGMA, At. H_2
ERN7B.....	Nickel-molybdenum	Hastelloy B	At. H_2, IGMA, Sub Arc
ERN7C.....	Nickel-molybdenum-chromium (Cr 14.5–16.5, Mo 15–17, W 3.00)	Hastelloy C	At. H_2, IGMA, Sub Arc
ERN7W.....	Nickel-molybdenum-chromium (Cr 4–6, Mo 23–26, W 0)	Hastelloy W[h]	At. H_2, IGMA, Sub Arc

[a] These rods and electrodes are used to weld alloys of similar composition.
[b] For the IGMA process, argon and d.c. reversed polarity are preferred for electrodes; either argon or helium and d.c. straight polarity with rods. Welding method symbols used are: OG = oxyacetylene; IGMA = inert-gas metal arc; At. H_2 = atomic hydrogen; Sub Arc = submerged arc.
[c] Gross porosity usually results when arc welding is employed.
[d] Do not use inert-gas metal arc method on sheet ⅛ in. thick and heavier.
[e] Used to weld monel which has 55–60% Ni, or any monel when absence of flux desirable.
[f] Responds to age hardening.
[g] Used to weld Inconel X and Inconel W.
[h] Used to weld such dissimilar metal combinations as Cr-Ni-Fe steels to cast cobalt alloys.

9—ALUMINUM AND ALUMINUM ALLOY RODS AND ELECTRODES

AWS-ASTM Class ↓	Major Composition As Manufactured	Alloys Welded[a]
BARE ELECTRODES AND RODS[b]		
R-996A, E-996A.....	Al 99.6 min	996A
R-990A, E-990A.....	Al 99.0 min	990A, M1A, G1A, clad M1A
R-C4A.....	Cu 4.0–5.0	CS42A, C4A
R-CN42A.....	Cu 3.5–4.5, Ni 1.7–2.3	CN42A
R-CS41A, E-CS41A...	Cu 3.9–5.0, Si 0.50–1.2	Clad CS41A
R-G1A, E-G1A.....	Mg 1.0–1.8	M1A, G1A, clad M1A
R-GM50A, E-Gm50A.	Mg 4.9–5.6, Mn 0.05–0.20	MG11A, Gr20A, clad MG11A, GS42A, GS11A
R-GR20A, E-GR20A.	Mg 2.2–2.8, Cr 0.15–0.35	MG11A, GR20A, clad MG11A
R-GR40A, E-GR40A..	Mg 3.1–3.9, Cr 0.15–0.35	MG11A, GR20A, GS11A, clad MG11A, GS42A, GR40A
R-MG11A, E-MG11A.	Mn 1.0–1.5, Mg 0.8–1.3	MG11A, clad MG11A
R-S5B, E-S5B.....	Si 4.5–6.0, Bi 0.05	M1A, MG11A, G1A, GR20A, CS11A, clad M1A, clad MG11A, S5A
R-SC51A.....	Si 4.5–5.5, Cu 1.0–1.5	SC51A
R-SG70A.....	Si 6.5–7.5, Mg 0.20–0.40	SG70A
R-ZG61A.....	Zn 5.2–6.0, Mg 0.50–0.65	ZG61A
COVERED ELECTRODES[c]		
Al-2.....	Al 99.0 min	Pure aluminum (min ten str 12,000 psi)
Al-43.....	Si 4.5–6.0, Al bal	General purpose (min ten str 14,000 psi)

[a] These ASTM alloy designations apply to all forms except die castings.
[b] Welding methods include gas, shielded carbon arc, inert-gas metal arc and atomic hydrogen.
[c] Used with d.c. current, preferably in flat position.

Adhesives

Selection

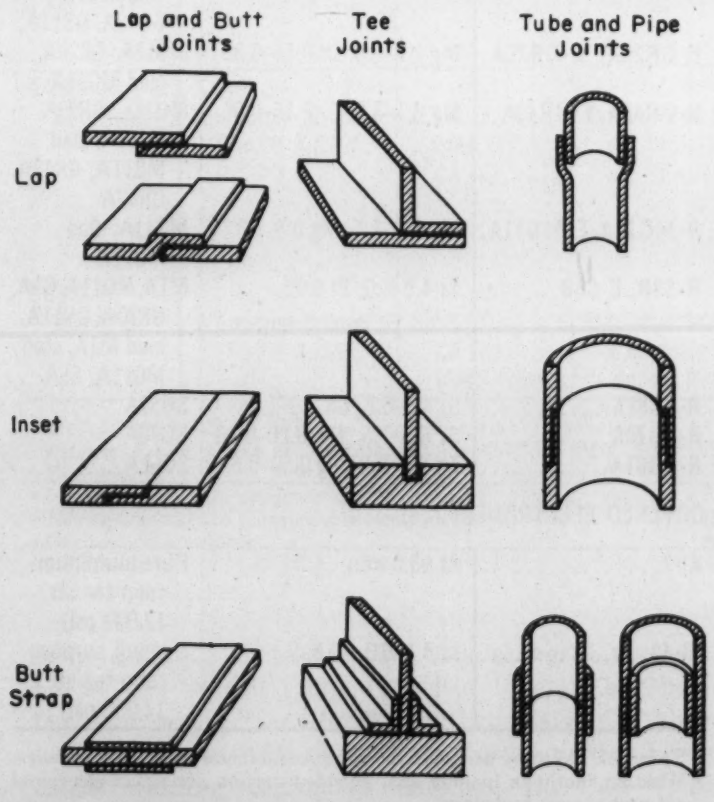
Classification. There are many ways to classify adhesives, none of which is satisfactory by itself. The five tables included here, each using a different breakdown, must therefore be referred to as a group. Classifying by chemical composition (Table 1) is most usual, but the newer modified compounds are omitted because they represent the blending of several chemical groups, and because the use of tradenames often obscures the chemical designation. In addition, in only a limited sense is the relationship between the type of materials being joined and the chemical type of the modified compounds a factor in selecting the adhesive.

These new adhesive "alloys" include: phenolic elastomers (e.g., phenolic-neoprene, phenolic-Buna N); vinyl phenolics (phenolic-vinyl, phenolic-polyvinyl butyral, phenolic-polyvinyl formal); modified epoxies (epoxy-phenolic, epoxy-polyamide, epoxy-polysulfide).

The other four tables apply to the single-resin adhesives as well as to these new modified compounds. In addition there are two factors which must be given more attention than the tables indicate:

Time. All classifications (as well as tack and bond strength properties) are related to time in various ways—shelf and pot life, tack life, length of time of application of heat and pressure, time lapse before handling parts, time lapse before end service.

End service conditions. Only by knowing and considering all the factors of end service, as well as all factors discussed in the tables here, can the formulator recommend a particular chemical composition with particular bonding requirements, vehicle, form and flowability. New formulations are devised where necessary. Also, it is not uncommon to use *two* adhesive formulations (allowing the first to dry before applying the second) to obtain the desirable advantages of each, or to obviate an undesirable effect of contact between the second adhesive and the surface.



***Some examples** of good joint design.*

Definitions

Emulsion. Adhesive type in which basic resin is a water-insoluble liquid (or solid particles) stably dispersed in water. Emulsifying agents are added to decrease surface tension. Some emulsions also contain a small amount of solvents (5%) to increase tackiness and improve water resistance.

Glue line thickness. Thickness of the fully dried adhesive layer.

Lay down thickness. Thickness of the applied wet adhesive coating.

100% reactive. Also "100% solids." Generally a modified epoxy resin-base paste, this adhesive type contains no solvent and cures at room temperature or higher.

Pot life. Length of time adhesive remains usable after being put into serviceable condition.

Shelf life. Length of time adhesive can be stored without deterioration (also known as "can stability").

Solvent dispersion. Adhesive type in which basic resin is in solvent solution and bonding is done by evaporation of the solvent (solvent release). A wide variety of solvents are used: ketones, toluol, naphtha, hydrocarbons, alcohol, acetone, etc. Solvent content generally varies from 10 to 50% for thermoplastic and thermosetting adhesives, from 50 to 95% for elastomeric.

Tack. The charateristic ("stickiness") that causes one surface, coated with adhesive, to adhere to another upon contact. Tack time may range from a few seconds to an almost indefinite period.

Wet strength. The bond strength realized immediately after adhesive-coated surfaces are joined and before cure occurs.

Methods

Adhesive bonding lends itself to complex automatic set-ups using spray guns, flow guns, paint rollers, etc. to apply the adhesive; pressure rolls, heavy presses, ovens, autoclaves, etc. to develop the bond. However, hand bonding with solvent-dispersed adhesives is common, and an understanding of the five steps involved can be applied to other methods:

1. **Surface preparation**—Surfaces should be smooth; must be clean and dry. Precleaning generally involves abrasive or chemical cleaning (ceramics, metals), light sanding (wood), chemical removal of mold release or plasticizer bloom (rubber, plastics), etc.

2. **Adhesive preparation**—Placing adhesive in a serviceable state may require mixing, thinning, reactivating, etc.

3. **Applying adhesive**—Varies from sticking coated film or tape or nameplate in place to use of trowel, squeeze bottle, hand roller, brush, etc.

1—CLASSIFIED BY CHEMICAL COMPOSITION GROUP

Type ➡	Natural	Thermoplastic	Thermosetting	Elastomeric
Examples of Type	Casein, blood albumin, hide, bone, fish, starch (plain and modified); rosin, shellac, asphalt; inorganic (sodium silicate, litharge-glycerin)	Polyvinyl acetate, polyvinyl alcohol, acrylic, cellulose nitrate, asphalt, oleoresin	Phenolic, resorcinol, phenol-resorcinol, epoxy, urea, melamine, alkyd	Natural rubber, reclaim rubber, butadiene-styrene (GR-S), neoprene, acrylonitrile-butadiene (Buna-N), silicone
Most Used Form	Liquid, powder	Liquid, some dry film	Liquid, but all forms common	Liquid, some tape
Common Further Classifications	By vehicle (water emulsion is most common but many types are solvent dispersions)	By vehicle (most are solvent dispersions or water emulsions)	By bonding requirements (heat and/or pressure most common but some are catalyst types)	By bonding req (all are common). Also by vehicle (most are solvent dispersions or water emulsions)
Bond Characteristics	Wide range, but generally low strength; good res to heat, chemicals	Good to 150–200 F; poor creep strength; fair peel strength	Good to 200–500 F; good creep strength; fair peel strength	Good to 150–400 F; never melt completely; low strength; high flexibility
Major Type of Use	Household, general purpose, quick set, long shelf life	Unstressed joints; designs with caps, overlaps, stiffeners	Stressed joints at slightly elevated temp	Unstressed joints on lightweight materials; joints in flexure
Materials Most Commonly Bonded	Wood (furniture), paper, cork, liners, packaging (food), textiles, some metals and plastics. Industrial uses giving way to newer types, esp in woodworking	Formulation range covers all materials, but emphasis on nonmetallics, esp wood, leather, cork, paper, etc., because these are less likely to require stressed joints	Depends greatly on specific type: epoxies for dissimilar materials and plastics; phenolics for metal, glass and wood; ureas and melamines extensively for wood; alkyds for metal laminations.	Few used "straight" for wood, rubber, fabric, foil, paper, leather, plastics films; also as tapes. Most modified with synthetic resins

2—CLASSIFIED BY BONDING TYPE[a]

General Type ⬇	Specific Types Available[b]	Forms Used	Remarks
Heat	Rm temp to 450-F types available; 250 to 350-F types most common	Formulated in all forms; liquid most common	Applying heat will usually increase the bond strength of any adhesive, even rm temp types
Pressure	Contact to 500-psi types available; 25 to 200-psi types most common	Formulated in all forms; liquid + powder most common	Pressure types usually have greater strength (not true of modified epoxies)
Time	Types requiring a few seconds to a week available; ½ to 24-hr types most common	Formulated in all forms	Time required varies with pressure and temp applied and immediate strength
Catalyst	Extremely varied in terms of chemical catalyst required; may also contain thinners, etc.	Two components—paste (or liquid) + liquid	Sometimes catalyst types may require elevated temp (<212 F) and/or pressure instead of, or in addition to, a chemical agent
Vulcanizing	Varied types requiring addition of a chemical agent (usually sulfur); may also contain a catalyst	Two liquid components	Premixed types requiring 250 to 350 F for vulcanization are available
Reactivation	Types requiring heat or solvent or second coating of adhesive	Dry film or previously applied liquid	Heat type is best for nonporous surfaces and/or max strength

[a] Formulations may be a combination of two or more of these types.
[b] Types stated as being most common refer to modified or "alloy" adhesive compounds.

4. Assembly—Accomplished during tack life of adhesive (5 min to 1 hr for porous surfaces, but can be extended) or after reactivating dried coating.

5. Bond development—Drying out of the solvent usually takes 1 to 60 min. Heat can be applied by warm air, infrared lamps or hot plate; pressure by

continued

Adhesives—concluded

3—CLASSIFIED BY VEHICLE[a]

Type ➡	Solvent Dispersion	Water Emulsion	100% Reactive ("100% solids")
Form	Liquids, pastes, tapes, supported films	Liquids	Pastes, films
Adhesive Alloy	Elastomer (rubber or vinyl butyral) + thermosetting resin (phenolic, sometimes epoxy or alkyd)	Reclaimed rubber + asphalt; milk latex	Usually modified epoxies (others for films)
Bonding Requirements	Usually pressure and/or heat, solvents (reactivation type)	Heat and/or pressure	Contact pressure; choice of rm temp or heat curing
Advantages	Flowability; easy to apply in film or tape form and from dispensing bottles. Can be reactivated after drying. Allows widest choice to formulator	Most inexpensive of the three. Eliminates fire hazard. Consistency can be varied by adding water	No time wait for solvent release. Eliminates fire hazard. No attack on vulnerable adherends. High heat resistance. Fills voids
Limitations	Care must be taken to allow for solvent release if both surfaces are nonporous (not usually recommended). Solvent may interact unfavorably with certain plastics	Usually limited to bonding where at least one surface is nonporous. Some types require high pressure. Freezing damages bonding properties	Peel, stretch and impact properties not usually as high as in others. Not freely flowing. Usually supplied as two-component adhesive requiring mixing. High shear strength falls rapidly above specified temp
Remarks	Elastomer adds flexibility, peel and impact strength	Curing characteristics highly influenced by added modifiers	Highly suited for metal-to-metal bonds, electrical uses

[a] This method of classification is the most common for modified compounds, but omits "contact-bond" and "pressure-sensitive" adhesives. Contact-bond adhesives adhere to themselves for a specified period of time after the coating has dried. Pressure-sensitive types adhere to almost any surface for an almost indefinite period of time after drying.

4—CLASSIFIED BY FORM

Type ➡	Remarks	Advantages
Liquid	Most common form; practically every formulation available. Principally solvent-dispersed	Easy to apply. Viscosity often under control of user. Major form for hand application
Paste	Wide range of consistencies. Limited formulations; principally 100% solids modified epoxies	Lends itself to high production set-ups because of less time wait. High shear and creep strengths
Powder	Require mixing or heating to activate curing	Longer shelf life; mixed in quantities needed
Mastic	Applied with trowel	Void-filling, nonflowing
Film, tape	Limited to flat surfaces, wide range of curing ease	Quick and easy application. No waste or runover; uniform thickness
Other	Rods, supported tapes, precoated copper for printed circuits, etc.	Ease of application and cure for particular use

5—CLASSIFIED BY FLOWABILITY[a]

Type ➡	Form or Vehicle Type	Advantages
Flow	Liquid, light or heated pastes, solvent dispersion, water emulsion	Fills crevices, fills complex joints, evens glue line, smooths surface
Nonflow	Heavy paste, trowelable mastic, void-filling epoxy, 100% solids	Applies vertically, requires no "clean-up," fills voids and gaps, does not sag

[a] There is no fine line of distinction between these types. In addition, flowability is affected by such factors as: temperature, pressure, joint design, time left standing, mixing of catalysts or solvents.

weighted hand rollers, metal weights or squeeze rolls. With nonporous surfaces, solvent must be dried out before final assembly pressure; for such application heat reactivation types are often used (applying heat and/or pressure after assembly of dried coated parts), but stronger bonds are developed by using 100%-reactive adhesives rather than solvent-dispersed.

Joint Design

Joints should be designed to keep the adhesive in shear and avoid cleavage and peel stresses. Typical good joint designs are shown by the accompanying sketches.

The type of strength under consideration (particularly peel vs shear) is extremely important in adhesive bonding.

Joint properties are also a function of the thickness of the glue line. Shear and creep strength are highest for thin films (0.001 to 0.003 in.), but heavier films may exhibit higher flexibility, toughness and cleavage strength.

Because there are so many factors involved in adhesive selection, compromise may be necessary. To aid the formulator in making this compromise, and to minimize cost, safety factors included in specifications should be only as high as absolutely necessary.

Mechanical Fasteners

Mechanical fastening is the most versatile and most widely used method for joining materials and parts. In the broadest sense, mechanical fasteners can be classified in two groups: threaded types (semipermanent) and rivets (permanent).

Threaded Fasteners

Types. The accompanying table describes the most common types of threaded fasteners (including washers). Some other types include:

Screws—In addition to variations (e.g., spanner heads, wing heads, split points), of every screw described, there are many special types, such as: sealing, twin head, one-way set and load-indicating.

Bolts—Many special head variations are available for the bolts described. Two important types not listed are sealing bolts (designed with an integral rubber washer under the head) and blind bolts (expander nut pulled back into sleeve by hydraulic gun, then core bolt inserted). Still more specialized bolts include: track, blow, tap, bent, load-indicating, crating, rib, and drive and locking stud bolts.

Nuts—There are nuts to mate with almost every type of bolt described. Other types include: acorn, anchor, clinch weldments (attached by spot welding), roofing, wing or thumb, and grommets.

Washers—Special types include: countersunk, sealing, sleeve, load-indicating, pipe and laminated.

Thread series. Most common threads are designated "Unified and American" and are either "coarse" or "fine," depending on the number of threads per inch for a specific diameter. The coarse series is for general use where quick assembly is desired; the fine series for aeronautical and similar work. Other series (e.g., 8-thread), as well as other standards (e.g., Whitworth), are in use.

Thread class. Class refers to the tolerance in manufacture and to the allowances permissible. The majority of screws and bolts are produced to class 2A (external tolerances and positive allowances); nuts to 2B (internal tolerances). Where closeness of fit is required, classes 3A and 3B may be used. Various fits are obtained by combining male and female threads of different classes.

Materials. Although the use of low carbon steel is widespread, all common metals, as well as some thermoplastics, are used in critical applications. To obviate galvanic corrosion, it is often desirable to use fasteners made from a material similar to those being joined. However, the corrosive effect must be weighed against such factors as increased strength and greater holding power.

Screws—Carbon and stainless steels, brass, silicon bronze and aluminum are often standard or available on order. Special materials available in limited types include die cast zinc alloys and several thermoplastics (nylon is most common). Zinc and cadmium-plated screws are often standard, and other electroplates are available on order. Other finishes and coatings include anodized, carbonized and black oxide.

Bolts and nuts—Carbon, alloy and stainless steels are standard for almost every type, but brass, naval bronze, monel and aluminum are often standard as well. Special materials available in some types include: malleable iron, silicon bronze, titanium, sintered brass, nylon and other thermoplastics. Finishes and coatings include those available for screws. Nuts, however, are often supplied with one of the following additional finishes: nickel and silver-plated, molybdenum disulfide, chromate, phosphate, and chromium oxide diffusion.

Washers—Most standard nut materials are also used for washers. Special materials include chromium-molybdenum steel, galvanized steel, vulcanized fibre and extruded nylon. Sealing washers generally are rubber—natural, silicone, neoprene or nitrile. Standard electroplated finish is usually cadmium, but zinc, nickel, tin, copper and chromium are not uncommon. Other finishes include phosphate and oil.

Design. Details of design depend upon many factors, including the type, style and material of the fastener which has been selected after consideration of end service conditions, materials being joined, speed and ease of assembly required, and ease and frequency of disassembly required. Loading should be in shear rather than tension. When assembly of the fastener requires that pressure, sharp blows or torque be applied to one side of the joint, that side should be the one having the thicker or harder material.

Descriptive nomenclature. Threaded fasteners are available with many types of shanks, heads, locking devices, etc.—some standardized and many not—which makes it impractical to define the hundreds of terms used. In addition, fastener terminology is apt to be overlapping, making it difficult, in theory, to distinguish between such items as bolts and screws, or machine screws and certain cap screws. Recent standards, for instance, include stove bolts with machine screws.

In the accompanying tables types have been distinguished according to general practice, rather than theory, as much as possible. In addition, the word "top" has been coined. Industry uses the word "head" for two purposes: to refer to the shape (generally as viewed from the side), and to refer to the design for a particular tool (generally recognizable by viewing from the top). The word "top" used in the tables refers to the latter. For example, a slotted round head (round as viewed from the top and slotted on top for a conventional screwdriver) is listed here as: top—slotted, head—round.

Rivets

Riveting is the fastest production fastening method of producing fairly strong joints with unskilled labor, yet with a high degree of consistency. Rivets are driven either hot or cold, by hammering or peening or by applying steady pressure from one or both sides. The shear strength of solid rivet joints is equal to or higher than that of most common threaded fasteners. Tubular and split are lower in strength, particularly tensile.

Design factors are similar to those for threaded fasteners. Joints are either lap or butt (using butt strap). Minimum recommended rivet spacing is usually three times the body diameter of the rivet. Allowable distances from edges are usually based on the rivet body diameter; 1½D for hot-driven rivets and 2D for cold-driven.

Materials from which rivets are fabricated include iron, low carbon steel, stainless steel, brass, copper, monel, aluminum, nickel silver and several thermoplastics. Coatings and finishes of all types can be ordered.

The accompanying table describes the most common types of rivets.

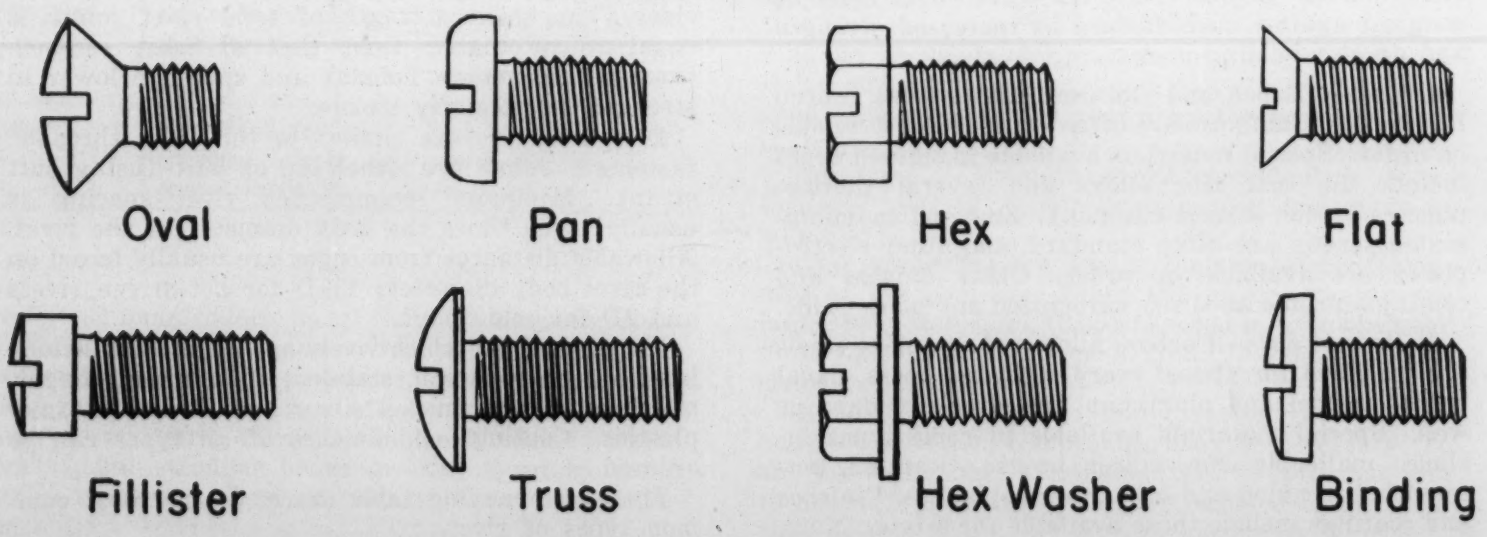
continued

Mechanical Fasteners—continued

THREADED FASTENERS

Type ↓	Description	Made of . . .	Selection Features	Uses
SCREWS				
Wood	Top—slotted or cross-recessed. Head—flat, round or oval. Thread—single, some double; point—gimlet. Also drive screws, hanger bolts, dowel screws	Low and medium carbon steels; alloy and stainless steel, monel, others	General use	Wood, and thin sheets of other material to wood
Cap	Top—hex or fluted socket; head—smooth or knurled. Top—slotted; head—round, flat, fillister or hex. Thread—coarse or fine; 8-thread; point-chamfer. Also top—plain; head—hex or knurled	Carbon and stainless steel, brass, bronze, monel, aluminum	General use with tapped holes or nuts. Shank usually not fully threaded. Socket type (most used) has closer fit than machine screws	Fastening metal parts and components
Machine	Top—slotted or cross-recessed; head—round, flat, oval, undercut (flat or oval), fillister, truss, binding or pan. Also hex heads, tops plain or slotted. Thread—coarse or fine; point—sheared	Carbon and stainless steel, brass, silicon bronze, monel, aluminum	Same as cap, but usually full-thread shank and smaller dia. Slotted type most used, generally with nut	Same as cap
Tapping (thread-forming)	ASA "A": Top—slotted or recessed; head—flat, oval, round, pan, fillister, truss or hex; thread—spaced; point—gimlet. "B": Same but blunt point. "BP": Same but cone point. "C": Same but blunt tapered point and machine thread	Case hardened steel; others on special order	A—general sheet metal screw; B—heavier duty; BP—misaligned parts; C—higher strength	All—Sheet metal, wood, asbestos, cloth to sheet metal. C—Cast iron, zinc die castings, steel, bronze and brass forgings, plastics
	Drive screws. 1) Top—plain; head—round; point—dog; thread—multiple with large helix angle. 2) Top—plain; head—pan; point—cone; thread—annular in upper section, but lower section has multiple threads with large helix angle	Case hardened steel; others on special order	Forms mating thread as hammered or pressed; can be applied with hopper-fed machines	Permanent fastenings. 1) Castings, heavy-gage sheet, plastics. 2) Fabric, leather or fiber to sheet metal
Thread-Cutting	ASA "D", "F", "G" and "T": Top—slotted or recessed; head—flat, oval, round, pan, truss or hex; thread—machine; point—blunt. Types differ in cutting edge: D—one off-center slot; F—several flutes; C—one centered through-slot; T—one wide slot. ASA "BF", "BG" and "BT" similar to F, G and T, respectively, but have spaced thread	Case hardened steel; stainless steel on special order	Minimum driving torque; fewer chips; increased resistance to stripping out	As above, but thin sections, particularly bosses in brittle plastics, plywood
Lock	Various proprietary types, such as: 1) preassembled lead washer; 2) variation of A.N. thread form; 3) longitudinal insert; 4) nylon pellet insert; and 5) annular expansion insert. Other types include: preassembled screw and lock washer, screw with locking teeth under head, slotted head fitting into counterbored hole with insert forced into slot. Also, liquid sealants used with standard screws	1—Heat treated alloy steel. 2—All std screw mtls. 3—Steel (incl stainless), brass, aluminum; insert is fluorocarbon plastic. 4—Carbon and stainless steel, aluminum alloy, brass, bronze. 5—Heat treated alloy steel; insert is bronze	1—Washer extrudes around tapered head. 2—Locks on full length of thread by reforming mating thread. 3—Insert does not project, has gradual torque build-up. 4—Insert projects slightly, locks whether or not screw is seated. 5—Insert expands when compressed, remains when screw is removed	Widely used, esp in mass production. Various types allow joining all metals and many plastics. Particular use depends on such factors as: permanent or disassembly; ease of assembly; amount of torque to assemble or disassemble; type of stress—rotational, vibration, thermal; sealing properties

MACHINE SCREW HEADS



THREADED FASTENERS—continued

Type ↓	Description	Made of . . .	Selection Features	Uses
BOLTS AND NUTS				
Regular (general use)	External hexagon or square head, generally used with nut of same shape. "Regular"—unfinished (not machined on any surface except threads); coarse threads. "Regular semifinished"—bolt heads and nuts are machined on bearing surface to provide washer face (or nuts may have chamfered corners); coarse threads. "Finished"—same as regular semifinished but closer body tolerance; threads—coarse, fine and 8-thread. Std machine screw nut is "regular", but has smaller diameter holes	Carbon and alloy steel, stainless steel, brass, naval bronze, monel, aluminum	Longer bolts are similar to hexagon cap screws, shorter to hexagon machine screws, but the hex head is more common with bolts, as is the use of nuts. Bolts come in greater standard lengths, are sturdier (larger body diameter and head height), and are classified in a different manner. Also, unlike screws, the bolt head is usually held while the nut is turned	Widely used for all materials. For larger parts and greater stresses than screws. Where material too soft or hard, or too thin, to be tapped. Where threaded shanks easily accessible
Heavy (heavy duty)	As above, but bolt heads and nuts are thicker and also wider across flats. Minimum standard bolt length is longer. Types are: Heavy (unfinished), Heavy Semifinished and Heavy Finished	Same as above		As above, but where more strength is required, or where holes have larger clearances, or where greater length required
Jam Nut	Similar to Regular or Heavy, but thinner	Same as above	Higher shear str; lower ten str than above	Often used with full nut for locking action
Lag Bolt	Head—square; point—gimlet or cone. Also known as lag screw	Low carbon steel	—	Fasten wood together or any material to masonry
Round Head Bolt	Two body styles (std dia and undersized) with coarse threads. Bolts include: 1) round head, square neck; 2) round head, short square neck; 3) round head, ribbed neck; 4) round head, fin neck; 5) 114-deg-countersunk square neck; 6) round head; 7) elevator (flat, large dia head; square neck); 8) ribbed head—slotted and unslotted; 9) step (like elevator but round head); 10) countersunk	Carbon and alloy steel, stainless steel, brass, naval bronze, monel, aluminum	These bolts differ in the method used to prevent rotation during bolting. Each is inserted in a hole which mates with the neck. Head types are selected by appearance or need for flush tops	For 1) wood, 2) steel, 3) hard wood and plastics, 4) wood, 5) wood, 6) any material where there is no other way to prevent rotation, 7) soft materials, 8) flooring, 9) resilient materials to steel, 10) metal to wood
Stud Bolt (stud)	A stud is a rod threaded either completely or on both ends. Types include: tap end (one end to produce interference fit in tapped hole, other for nut); double end (both ends for nuts); continuous thread; hanger bolt (one end has lag screw thread)	Low carbon steel	Advantageous where length adjustment desirable	Widely used for castings (permanently assembled) and for soft metal and plastic parts
Place Bolt	Flexible zone is formed by slotted segments in the upper face of a hex bolt head and a circular recess in the lower face, providing a controlled spring action which increases elastic elongation. Same principle applied to cap screws	Carbon and alloy steel; others available	Provides resistance to loosening by vibration and minimizes fatigue failure. Used with and without nuts	Cylinder heads, flywheel housings, bearings (cap screw), connecting rods
Locknut	Huge variety of proprietary locknuts, most of which can be classified as one of the following types: 1) free-spinning (no locking action until seating begins, e.g., integral toothed washers), 2) prevailing torque (locking depends on some form of interference between male and female threads, e.g., deforming threads or forcing lead or angle), 3) spring action (designed to take advantage of natural spring of the material or with auxiliary springs, e.g., slotted segments; arched base with prongs to lock against threads)	Nuts—carbon steel generally std; also stainless, brass, monel, aluminum. Springs—heat treated spring steel usually std; also stainless, brass, phosphor bronze, beryllium copper. Inserts—bronze usually std; also brass, aluminum, steel	Locknuts remain tight under vibration and replace the use of wire or cotter pins in a hole drilled through bolt and nut. Each type designed for specific use in terms of materials, end service conditions, ease of assembly, etc.	Mass produced automobiles, appliances, machinery, aircraft, furniture, toys, etc.

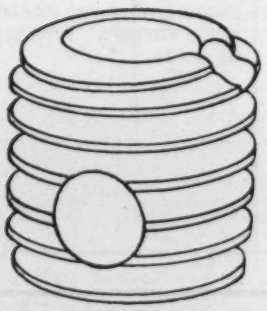
ROUND HEAD BOLTS

Mechanical Fasteners—concluded

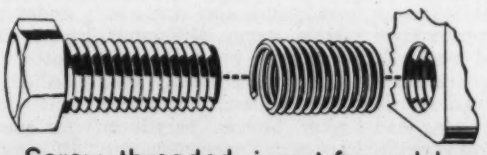
THREADED FASTENERS—concluded

Type ↓	Description	Made of . . .	Selection Features	Uses
WASHERS AND INSERTS				
Plain Washer	Plain, flat, circular washer standardized in o.d. and i.d. dimensions (ASAB27.2–1953) and with suggested thicknesses. Form series are: light, medium, heavy, extra heavy	Almost all materials used for nuts	Provide increased bearing surface for bolt heads or nuts, thus distributing load over larger area. Also prevent marring, improve appearance	Widely used with nuts and bolts
Lock Washer	Split spring type. Washer is split and shaped like a single turn of a slight helix. Free height is about twice the washer thickness; gap is small enough to prevent entangling. Same four series as plain washers	Carbon steel, stainless 302 or 420, aluminum-zinc alloy, phosphor and silicon bronze, K monel. Not all materials in all four series	Prevents loosening of bolt under vibration. Split-spring type allows occasional disassembly and reassembly; tang of helix may mar work surface	Widely used for most plain threaded screws and bolts
	Tooth type. Teeth on i.d., o.d. or both. Variety of shapes and tooth types designed for specific uses	Carbon steel, phosphor bronze	Same as above, but thinner than split-spring, not recommended for frequent disassembly	External tooth type for bolts; internal tooth type for screws
	Spring type. Some proprietary types: domed, conical, waved, countersunk, cap, folded rim, tab, irregular hole, wood spring	Medium carbon and stainless steel, bronze, aluminum, beryllium, copper, K monel	Provides strong locking with varied other features	Special uses, generally on softer materials
nsert	May be threaded bushings, studs, etc., cast or molded integrally with part. Many proprietary inserts are molded in or inserted after part is formed. Noncircular cross sections resist turning; undercuts resist tensile pull. Some types are: 1) slotted body, exterior fins, 2) slotted and tapered body containing four-eared disk below threaded portion, 3) spool-shaped spacer, 4) helical coil of diamond-shaped wire (also locking type with center loop of coil octagon-shaped), 5) disk-shaped with edge groove around middle, 6) threaded, with embedded nylon pellet, 7) two-piece: threaded insert and lock ring	1) Aluminum alloy, 2) brass, 3) aluminum alloy, 4) stainless, phosphor bronze, Hastelloy C, 5) brass, steel, stainless, aluminum, 6) low carbon steel, 7) low carbon steel. Most inserts can be obtained in other materials, e.g., brass, bronze, aluminum, monel	Added strength for soft materials. 1) Allows expansion pressure against hole and screw. 2) Disk is forced down to spread four tapered segments. 3) Through-bolt or threaded. 4) Coil has both internal and external thread; inserted in tapped hole. 5) Locked by swaging tool. 6) Uses standard screwdriver. 7) Outer teeth of lock ring broach into parent material	Limited to parts thick enough to hold insert. 1) Wood, plastics, soft metals. 2) Replace molded-in inserts. 3) Sandwich panels. 4) Where weight and wear are problems; used in damaged tapped holes. 5) Plastics sheet, soft sheet metal. 6) Nonferrous metals. 7) Hard materials (resists vibration and stress); soft materials (resists wear)

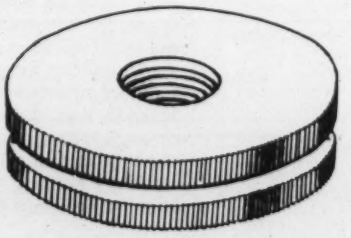
INSERTS



Threaded insert with embedded nylon pellet



Screw-threaded insert formed by coil of diamond-shaped wire

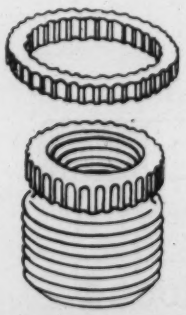


Disk-shaped insert with groove around middle

Slotted insert with exterior fins

Slotted, tapered, semi-threaded insert containing four-eared disk

Spool-shaped spacer

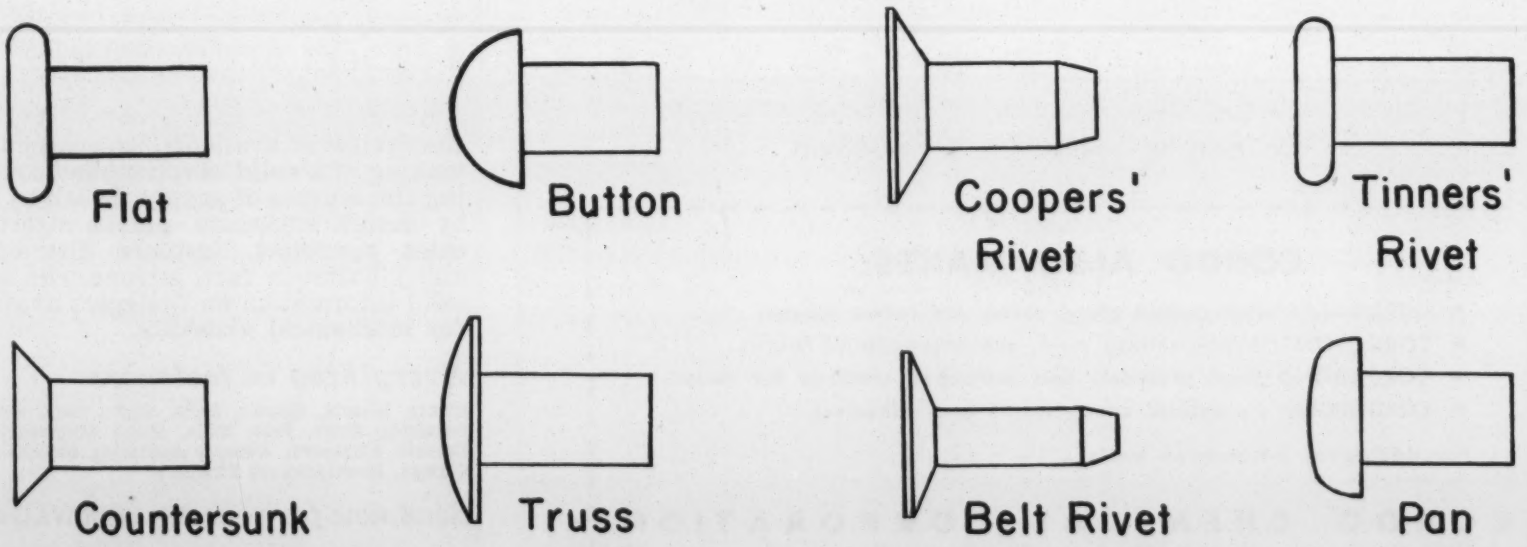


Threaded insert and lock ring

RIVETS, STITCHING AND STAPLING

Type ⬇	Description	Uses
RIVETS		
Large Solid	Dia from ½–1¾ in. Head—button, high button, cone, pan or countersunk (flat or round). Neck—straight or swell (exc countersunk). Special heads include: machine, globe, wheel, trunk. Wrought iron and steel are std mtls; others available	High production, permanent assembly operations requiring high tensile and shear strength and generally not requiring airtight or watertight joints. Aircraft, ships, trains, bus and truck bodies, etc.
Small Solid	Head—flat, countersunk, button, pan, truss, tinners', coopers' or belt	As above (generally cold riveting is used on small rivets, hot riveting on large)
Semi-Tubular	Shallow hole, extruded or drilled in shanks, does not exceed shank dia. Variety of heads include: oval, flat countersunk, tinners', cone	Where stress is low, or primarily shear. Metals, ceramics, hard plastics and woods; through predrilled or prepunched holes. Aircraft, cameras, toys
Tubular	Hole in shank is deeper than dia but less than ½ in. Rivet compresses material within shank. Head variety same as above	Where stress is low, or primarily shear. Leather, soft plastics, rubber, soft woods, fabrics. Leather cases, golf bags, sheet metal
Split	Slot milled in shank forms two sharp prongs that pierce material without weakening it	Where stress is low, or primarily shear. Light-gage metal, plastics, wood, fibreboard, leather
Shouldered	Shoulder beneath head is made to spec. Either coldformed or coldheaded and turned	Where pivot or bearing surface req within joined members. Automotive parts, vending machines
Blind	Proprietary types, of which most are one of these: 1) sleeve—either hollow (mandrel pulled back through; may be plugged if desired), or self-plugging (after mandrel is pulled through it is trimmed off to leave solid rivet); 2) pin driven through tapered hole in rivet to expand it, then lip peened over pin head; 3) type for which a special assembly tool is basic, e.g., a gun grips pull-through mandrel, clinches rivet, continues to pull until head or stem breaks; 4) explosive charge contained within shank is detonated (by riveting iron, etc.) to expand rivet to fill hole and form bulb on end. Materials are: cadmium-plated steel, aluminum alloy, brass, stainless, monel, etc.	Where backing up the rivet is impractical, usually due to inaccessibility. 1) Lends itself esp to automatic setting; hollow is not as strong but can be plugged by any mtl desired and with umbrella head to match design. 2) High shear str, good ten str. 3) High assembly rate; rivet has high str clinch but is not completely hole-filling. 4) Extremely high assembly rate; widely used to fasten both metals and nonmetallics; nearly equiv in str to solid rivet
Other	Some special rivets are: outside prong, compression, decorative spot, precious metal, brake lining	Special uses
METAL STITCHING AND OTHER FASTENERS		
Stitching and Stapling	Joining two or more materials with 18-gage wire fed from a coil, cut to length, formed, driven through and clinched. High assembly rate, but limited to thin parts, e.g., joining 0.093-in. aluminum strips. Loop clinches are best for nonstructural joints, flat clinches for stressed. Stapling differs in using preformed fasteners. Std mtls include high carbon steel, stainless, and phosphor bronze	For sheet and strip stock of all materials, but preferably joining soft nonmetallics to metal Also sandwich materials
Other Fasteners	Nails, spring clips, retaining rings, pins (straight, dowel, taper, clevis, cotter), quick-release fasteners (snap slides, hinges, hooks, latches), hose clamps, turnbuckles, masonry anchoring devices, vacuum tube retainers, etc.	Special uses

SMALL SOLID RIVET HEADS



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CORDOBOND ADHESIVES

No.	70	80	82	89D	153	FS219A
Type	Quick Bonding	Med. Speed Bond.	Med. Speed Bond.	Med. Speed Bond.	Med. Speed Bond.	Heat Seal Laminating
Wt/Gal.	8½	7½	7¾	7½	7⅓	7¾
Solids %	32	17	35	35	27	25
Method						
1. Brush	1	1	1	1	1	1
2. Spray	2	2	2	2	2	
3. Dip	3	3	3	3	3	3
4. Coat	4	4	4	4	4	4
Drying Conditions — All adhesives are air or forced heat dried (150°F)						
(Dry) Flow Temp.	250°	250°	250°	265°	260°	300°
Use	Gen'l Purp.	Gen'l Purp.	Spec. Purp.	Spec. Purp.	Spec. Purp.	Spec. Purp.
Plastics to	Wood Paper Plastics	Metal Polys-tyrene	Metal Polys-tyrene	Acetate Buty-rate Polys-tyrene	Vinyls to Vinyls	Metallized Mylar & Metal

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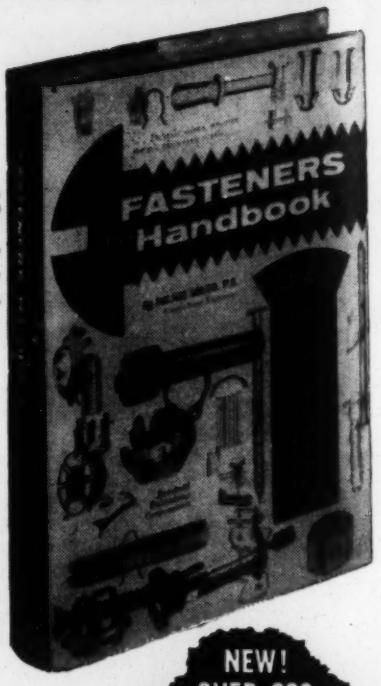
FASTENERS Handbook



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Directory Section

Suppliers of Materials 5

Addresses of Suppliers 6

THE DIRECTORY

This Directory is designed to be a comprehensive and up-to-date source of suppliers of engineering materials, forms, finishes and closely related services. The listings were compiled from information received from more than 3000 manufacturers, from official information made available by trade associations, and from many other sources.

HOW TO USE THE DIRECTORY

The Directory consists of two sections. In the first, Section 5, the categories of materials, forms, finishes and related services are arranged alphabetically; suppliers in each category also are listed alphabetically with their geographical location indicated by state abbreviations. The many cross references make it easy to find any given category. In general, suppliers of basic or "mill" forms of materials, such as sheet, are listed under the particular materials, whereas suppliers of "fabricated" forms, such as forgings, are listed under the form.

Key letters in parenthesis following names of suppliers provide two kinds of additional information: 1) the basic materials in which a supplier furnishes a particular fabricated form, and 2) the basic forms in which a supplier furnishes a particular material (see key at right). For example, if you are looking for suppliers of magnesium sand castings, you will look for those suppliers of sand castings whose names are followed by the letter "e." Similarly, if you are looking for suppliers of cellulose acetate rod, you will look for those suppliers of cellulose acetate whose names are followed by the letters "bb."

Further information on a particular supplier's product can often be found by consulting an advertisement in this issue. Advertisers' names are bold-faced, and the pages on which their advertisements appear are listed following their name in the appropriate category. Page numbers of advertisements are also given in the complete index to advertisers on p 403.

The second part of the Directory, Section 6, contains a complete alphabetical list of suppliers and their addresses. To find the address of a division of a company, look up the name of the parent company (always given with the division name in Section 5).

In compiling a directory of this nature it is impossible to avoid errors and omissions. We plan to constantly improve this directory in future editions and we will welcome corrections and suggestions. Please address them to Directory Editor, Materials in Design Engineering, 430 Park Ave., New York 22, N. Y.

MATERIALS

a Aluminum and its alloys
b Copper and its alloys
c Iron and its alloys (except steel)
d Lead and its alloys
e Magnesium and its alloys
f Nickel and its alloys
g Steels
h Titanium and its alloys
j Zinc and its alloys
k Thermoplastics
l Thermosetting plastics
m Elastomers

BASIC FORMS

n Anodes
o Bar
p Base resins, polymers or gums
q Billets
r Custom formed parts (incl. specialties)
s Fibers
t Film
u Foams (component materials or products)
v Foil
w Ingot
x Laminating, casting resins
y Molding compounds
z Plate
aa Powder
bb Rod
cc Sheet
dd Strip
ee Tubing
ff Wire

The listings and other data in this directory are compiled from sources believed reliable by the publisher. The publisher, however, does not represent or guarantee the accuracy of said listings and data, and no responsibility is assumed therefor.

Suppliers of Materials

Acetal Plastics

Albany Novelty Mfg. Co., Mass (t,cc)
Anderson Assoc., Inc., Ohio (y)
Bamberger, Claude P., Inc., NJ (y)
Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)
du Pont de Nemours, E.I. & Co., Inc., Polychemicals Dept., Del (p,x,y)
Shawinigan Resins Corp., Mass (p)
Superior Plastics, Inc., Ill (bb,cc,ee)

Acetate

(see Cellulose Acetate)

Acrylate Rubber

(see Acrylic Rubber)

Acrylic Plastics

Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (t,bb,cc)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Assoc., Inc., Ohio (y)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (y)
Blank, Arthur & Co., Inc., Mass (cc)
Borden Co., Borden Chemical Div., NY (p)
Cadillac Plastic & Chemical Co., Mich (p,x,bb,cc,dd,ee)
Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Cast Optics Corp., NJ (cc)—Ad pp 204-205
Celanese Corp. of America, Plastics Div., NJ (p)
Chemical Development Corp., Mass (p)
Colonial Kolonite Co., Ill (bb,cc,ee)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (p)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)—Ad p 182
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (bb,cc,dd, ee)
Dow Chemical Co., Plastics Div., Mich (s)
du Pont de Nemours, E.I. & Co., Inc., Polychemicals Dept., Del (p,x,y)
Dura Plastics of New York, Inc., NY (bb,cc.dd,ee)
Eastman Chemical Products, Inc., Tenn (s)
Eljay Corp., Md (bb,cc,dd,ee)
Foss Mfg. Co., Plastics Div., Id (cc)
Fry Plastics Co., Calif (bb,cc)
Gallgher Co., Utah (bb,cc,dd,ee)
General Aniline & Film Corp., NY (cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Gering Products, Inc., NJ (y)
H & R Industries, Pa (bb,cc,dd,ee)
Industrial Plastics Corp., Ind (bb,dd)
Industrial Products Suppliers, NJ (cc, dd)
Jet Specialties Co., Inc., Calif (bb, dd,ee)
K S H Plastics, Inc., Mo (bb,cc,dd)
Luminous Resins, Inc., Ill (y)
Midwest Plastic Products Co., Ill (cc, dd)
Muehlstein, H. & Co., Inc., NY (p, y,cc)
Norrich Plastics Corp., NY (bb,cc,ee)
Perfex Plastics, Inc., Ill (bb,dd)
Philrus Products Co., NJ (bb,cc,dd, ee)
Plast-Ad Mfg. Co., Ind (bb,cc,dd,ee)
Plastic Materials, Inc., NY (y)
Pyramid Industries, Inc., Pa (ee)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (x)
Reed Plastics Corp., Mass (y)
Rohm & Haas Co., Pa (y,cc)—Ad p 201
Russell Mfg. Co., Conn (s)
Schwab Plastics Corp., Mich (bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Snyder Mfg. Co., Inc., Ohio (cc)
Southern Plastics Co., SC (bb,cc,dd, ee)
Superior Plastics, Inc. Ill (bb,dd)
United Shoe Machinery Corp., Mass (p)
Western Felt Works, Ill (cc)
Westlake Plastics Co., Pa (t,y,bb,cc, dd,ee)
World Plastex, NY (bb,cc,dd)
World Plastics, NY (bb,cc,dd,ee)

Acrylic Rubber

Adhesive Products Corp., NY (x)
Borden Co., Borden Chemical Div., NY (p)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb, cc,dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (cc)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Goodrich, B.F. Chemical Co., Ohio (p,cc)
Maloney, F.H. Co., Tex (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Norrich Plastics Corp., NY (bb,cc,dd, ee)
Parker-Hannifin Corp., Parker Seal Div., Ohio (u)
Polymer Chemical Co., Ohio (x)
Roth Rubber Co., Ill (cc)
Russell Mfg. Co., Conn (s)
Southern Plastics Co., SC (bb,cc,dd,ee)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y, bb,cc,dd,ee)

Acrylonitrile-Butadiene Rubber

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NY (bb,cc,dd)—Ad pp 196-7
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Anderson Assoc., Inc., Ohio (y)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Borden Co., Borden Chemical Div., NY (p)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago Molded Products Corp., Campco Div., Ill (cc)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)

du Pont de Nemours, E.I. & Co., Inc., Del (cc)
Faultless Rubber Co., Ohio (y,bb,ee)
Firestone Tire & Rubber Co., Ohio (p)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Chemical Co., Ohio (p,cc)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Goshen Rubber Co., Inc., Ind (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Lee Rubber & Tire Corp., Republic Rubber Div., Ohio (p,y,cc,dd,ee)
Lus-Trus Corp., Mich (cc)
Luzerne Rubber Co., NJ (bb,cc,dd)
Maloney, F.H. Co., Tex (y)
Marbon Chemical Div., Borg-Warner Corp., Ind (p,x,y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y,cc,dd)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,x,y)
Parker, Stearns & Co., Inc., NY (y,bb,cc,dd,ee)
Parker-Hannifin Corp., Parker Seal Div., Ohio (u)
Polymer Chemical Co., Ohio (x)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Saran Lined Pipe Co., Mich (y,cc)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., SC (bb,cc,dd,ee)
Stockwell Rubber Co., Inc., Pa (y,bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (u)
U.S. Rubber Co., NY (p)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Westlake Plastics Co., Pa (bb,cc,dd)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Adhesives

(see also Tapes)

Adhesive Products Corp., NY (k,l,m)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (l)
American Cyanamid Co., Plastics & Resins Div., NY (l)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Metaseal Corp., NJ (l)
American Products Mfg. Co., Inc., La (k,m)
Angier Adhesives Div., Interchemical Corp., Mass (k,l,m)
Arabol Mfg. Co., NY (k)
Aries Laboratories, Inc., NY (l)
Armour & Co., Adhesive Div., Ill (k,m)
Armstrong Cork Co., Pa (k,l,m)
Armstrong Products Co., Ind (l)
Atlas Mineral Products Co., Pa (k,l,m)
Avondale Co., Ill (k,l,m)
Babbitt Chemical Co., Inc., Mass (k)
Beck, I. & Sons, Inc., NY (m)
Belding Corticelli Industries, NY (k,l,m)
Belko Corp., Md (m)
Biggs, Carl H. Co., Inc., Calif (k,l)
Bisonite Co., Inc., NY (l)
Borden Co., Borden Chemical Div., NY (k,l,m)
California Metal Enameling Co., Calif (k,m)
Campro Co., Ohio (k)
Catalin Corp. of America, NY (l)
Chemical Coatings & Engineering Co., Inc., Pa (k,l,m)
Chemical Development Corp., Mass (k,l)
Chemical Process Co., Calif (l)
Chemical Products Corp., RI (k,m)
Chrysler Corp., Cycleweld Div., Mich (k,l,m)
Ciba Co., Inc., NY (l)
Colonial Kolonite Co., Ill (k)
Connecticut Hard Rubber Co., Conn (m)
Consoweld Corp., Wis (k)
Continental Can Co., Conolite Div., Del (l)
Cooper, Peter Corp., NY (k)
Cordo Chemical Corp., Conn (k,l,m)—Ad p 394
CrystalX Corp., Pa (k)
Dacar Chemical Products Co., Pa (k,l,m)
Dayton Rubber Co., Ohio (k,l,m)
Dennis Chemical Co., Mo (k,m)
Devcon Corp., Mass (k,l)
Douglas & Sturgess, Calif (l,m)
Dow Corning Corp., Mich (m)
du Pont de Nemours, E.I. & Co., Inc., Del (k)
Eastman Chemical Products, Inc., Tenn (k)
Electro Chemical Engineering & Mfg. Co., Pa (k,l,m)
Emerson & Cuming, Inc., Mass (k,l,m)
Everlite Corp., Wash (k,l,m)
Fanner Mfg. Co., Munray Products Div., Ohio (k)
Fasson Products, Ohio (l)
Federal Adhesives Corp., NY (k,l,m)
Flexfirm Products, Calif (k)
Foss Mfg. Co., Plastics Div., Id (l)
Franklin Glue Co., Ohio (k)
Fry Plastics Co., Calif (k,l)
Fuller, H.B. Co., Minn (k,l,m)
Furane Plastics, Inc., Calif (l)
General Electric Co., Silicone Products Dept., NY (k,l)
General Mills, Inc., Chemical Div., Ill (k,l)
General Plastics Mfg. Co., Wash (k,l,m)
Gomar Mfg. Co., Inc., NJ (k)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (k)
Grems Mfg. Co., Ore (k,m)
Hadley Bros.-Uhl Co., Mo (m)
Hardman, H.V. Co., Inc., NJ (l)—Ad p 398
Haskelite Mfg. Corp., Mich (k,l,m)
Haveg Industries, Inc., Del (l)
Hayes Adhesive Co., Inc., Mo (k,l)
Houghton Laboratories, Inc., NY (k,l,m)
Hughes Glue Co., Mich (k,l,m)
Industrial Polychemical Service, Calif (k,l,m)
Interchemical Corp., NY (k,l,m)
Jamestown Finishes, NY (k)
Johns-Manville Corp., Dutch Brand Div., Ill (m)
Kendall Co., Polyken Sales Div., Ill (k,l)
Lee Rubber & Tire Corp., Pa (m)
Lord Mfg. Co., Special Products Div., Pa (k,l,m)
Maas & Waldstein Co., NJ (k,l)
Magic Iron Cement Co., Ohio (k)
Magnesium Co. of America, Ind (k,l)
Maloney, F.H. Co., Tex (k,l,m)
Manhattan Adhesives Corp., NY (k,l,m)
Mansol Ceramics Co., NJ (l)
Marblette Corp., NY (l)
Marbon Chemical Div., Borg-Warner Corp., Ind (k,l)
Mesa Plastics Co., Calif (l)
Midland Adhesive & Chemical Corp., Mich (k,l,m)
Minneapolis Honeywell Regulator Co., Minn (l)
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich (k,l,m)
Monsanto Chemical Co., Plastics Div., Mass (l)
Morningstar-Paisley, Inc., NY (k,l)
Narmco Resins & Coatings Co., Calif (l,m)
National Casein Co., Ill (k,l)
National Starch Products, Inc., Structural Products Div., NY (k,l,m)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (k,l,m)
Nukem Products Corp., NY (k)
Ohio Adhesives Corp., Ohio (k,l,m)
Parker Paint Mfg. Corp., Ind (k)
Pawling Rubber Corp., NY (k,l)
Pecora, Inc., Pa (k,m)
Permacel-LePage's, Inc., NJ (k,l,m)
Perry-Austen Mfg. Co., NY (l,m)
Pierce & Stevens Chemical Corp., NY (k,l,m)
Plast-Ad Mfg. Co., Ind (k,l)
Poly Resins, Calif (l)
Polymer Chemical Co., Ohio (k,l,m)
Polymer Corp., Pa (k)
Presstite-Keystone Engineering Products Co., Mo (k,l,m)
Quelcor, Inc., Pa (l)
Randolph Products Co., NJ (k,l,m)
Raybestos-Manhattan, Inc., Adhesives Div., Conn (k,l,m)
Ren Plastics, Inc., Mich (l)
Rohm & Haas Co., Pa (k,l)
Rubber & Asbestos Corp., NJ (k,l,m)
Rubber & Plastics Compound Co., Inc., NY (k)
Sauereisen Cements Co., Pa (k,l)
Schwartz Chemical Co., Inc., NY (k,l,m)
Shell Chemical Corp., NY (l,m)
Snyder Mfg. Co., Inc., Ohio (k)
Southern Adhesives Corp., Va (k,l,m)
Standard Insulation Co., NJ (l)
Steelcote Mfg. Co., Mo (l)
Stockwell Rubber Co., Inc., Pa (m)
Superior Plastics, Inc., Ill (k)
Surprenant Mfg. Co., Mass (k)
Swedlow Plastics Co., Calif (l,m)
Synco Resins, Inc., Conn (k,l)
Toyad Corp., Pa (m)
U B S Chemical Corp., Mass (k,l,m)
Union Carbide Corp., Silicones Div., NY (l)
United Shoe Machinery Corp., Mass (k,l,m)
U.S. Stoneware Co., Ohio (k,l)
Waterman Industries, Inc., Calif (k,l)
Western Plastics Corp., Wash (k)
Westlake Plastics Co., Pa (k)
Williamson Adhesives, Inc., Ill (k,l,m)
Youngstown Sheet & Tube Co., Fiber-cast Div., Okla (l)

Alkyd Plastics

Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (y)
American Cyanamid Co., Plastics & Resins Div., NY (p)
Anderson Assoc., Inc., Ohio (y)
Archer-Daniels-Midland Co., Minn (p)
Booty Resineers, Inc., NJ (p)
Electrofilm, Inc., Calif (t)
Fiber Glass Industries, Inc., NY (u,x,y,cc)
Foss Mfg. Co., Plastics Div., Id (cc)
General Electric Co., Insulating Materials Dept., NY (p)
Glaskyd, Inc., Ohio (y)
Hays Mfg. Co., Pa (y)
Hercules Powder Co., Del (p)
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky (p)
Kurz Kasch, Inc., Ohio (y)
Naugatuck Chemical Div., U.S. Rubber Co., (p,x,y)
Panelyte Div., St. Regis Paper Co., NY (x,y)
Reichhold Chemicals, Inc., NY (p)
Schenectady Varnish Co., Inc., NY (p)
Sherwin-Williams Co., Ohio (p)
Specialty Resins Co., Calif (p)
Westinghouse Electric Corp., Micarta Div., SC (p)

Alloy Steels

(see Steel)

Aluminides

(see Refractories)

Aluminized Metals

(see Precoated Metals)

Aluminizing

(see Immersion Coatings)

Aluminum and Its Alloys

A & A Die Casting Co., Calif (cc)
Acme Tube, Inc., NJ (ee)
Adams Engineering Co., Inc., Fla (q,ee)
Advance Screw Products Co., Inc., Wis (o)
Advance Stamping Co., Mich (dd)
Aerolite Extrusion Co., Ohio (n,o,,bb,dd,ee)
Alabama Wire Co., Inc., Ala (ff)
Albert Pipe Supply Co., Inc., Foundation Div., NY (ee)
Alcasco Foundry, Ill (w)
Alloys & Chemicals Mfg. Co., Inc., Ohio (w,aa)
All-State Welding Alloys Co., Inc., NY (ff)
Alofs Mfg. Co., Mich (cc,dd,ff)
Alpha Metals, Inc., NJ (v)
Aluminium Ltd. Sales, Inc., NY (q,w)
Aluminum Co. of America, Pa (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Aluminum Billets, Inc., Ohio (q)
Aluminum Foils Co., Tenn (v)
American Brass Co., Conn (cc,dd,ee)
American Nickel Alloy Mfg. Corp., NY (w,aa)
American Sheet Metal Works, Inc., Conn (bb,cc,ee)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (w)
Anaconda Aluminum Co., Sub. of Anaconda Co., NY (w)
Apex Smelting Co., Ill (o,q,w,bb)
Arcos Corp., Pa (ff)
Armet Alloys, Inc., Ohio (w)
Arrow Metal Products Corp., NJ (cc)
Atlantic Steel Co., Ga (o,cc)
Auld, D.L. Co., Ohio (o,bb,cc,dd,ff)
Aurora Refining Co., Ill (w)
Babson Dow Mfg. Co., Mass (o)
Bay State Refining Co., Inc., Mass (w)
Belmont Smelting & Refining Works, Inc., NY (n,w,aa)—Ad p 130

Letters in ( ) indicate materials and forms—turn page for key

Biddle Screw Products Co., Ind (o, bb,ee)
Bohn Aluminum & Brass Corp., Mich (o,q,bb,ee)
Bonnell, William L. Co., Inc., Ga (bb,ee)
Both, A.O. Corp., Mass (aa)
Bridgeport Brass Co., Conn (o,bb,cc, dd,ee,ff)
Bridgeport Rolling Mills Co., Conn (dd)
Briel Industries, Inc., Ind (q,w)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc,dd,ee)
Budek & Bock Spring Mfg. Co., Ill (ff)
Caspers Tin Plate Co., Ill (cc,dd)
Castle, A.M. & Co., Ill (o,z,cc,dd)
Central Fabricators, Inc., Ohio (z,bb, cc,ee)
Channel Master Corp., NY (q,ee)
Clad-Rex Corp., Ill (cc)
Clark Perforating Co., Mich (cc,dd)
Clarksville Foundry & Machine Works, Tenn (o,w,z,ee)
Cleveland Electro Metals Co., Ohio (w)
Cochran Foil Co., Sub. of Anaconda Co., NY (v,cc,dd,ee)
Commercialores, Inc., SC (aa)
Copper & Brass Sales, Inc., Mich (o, v,z,bb,dd,ee,ff)
Corson Industries, Pa (q,bb,ee)
Dahlin, C.A. Co., Ill (cc,ee)
Designers Metal Corp., Ill (cc)
Dixie Aluminum Corp., Ga (o,bb)
Dormont Mfg. Co., Pa (ee)
Eastern Rolling Mills, Inc., NY (cc,dd)
Edgecomb Steel & Aluminum Corp., NJ (o,z,cc,dd,ee)
Empire Metal Co., NY (o,q,w)
Fairmont Aluminum Co., W. Va (cc, dd)
Federated Metals Div., American Smelting and Refining Co., NY (o, w)
Flynn, Michael Mfg. Co., Pa (o,bb,ee)
Foamalum Corp., Ill. (foamed)—Ad p 133
Frasse, Peter A. & Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (o,z, bb,cc,dd,ee,ff)
Frontier Bronze Corp., NY (w)
General Cable Corp., NY (ff)
General Extrusions, Inc.,Ohio (o,bb,ee)
General Smelting Co., Pa (w)
Gold Leaf & Metallic Powders, Inc., NY (aa)
Harbot Die Casting Corp., NJ (w)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum Div., Harvey Machine Co., Inc., Calif (o,q,w,bb,ee)
Hayden Wire Works, Inc., Mass (aa)
Hexcel Products, Inc., Calif (v)
Himmel Bros. Co., Conn (o)
Hokin Aluminum Co., Ill (o,bb)
Hommel, O. Co., Pa (aa)
Inshield Die & Stamping Co., Ohio (cc,dd)
Jackson Steel Products, Inc., NY (ee)
Jarl Extrusions, Inc., NY (o,q,bb,ee)
Jelliff, C.O. Mfg. Corp., Conn (ff)
Jobbins, William F., Inc., Ill (w)
Johnston Foil Mfg. Co., Mo (v,cc)
Kaiser Aluminum & Chemical Sales, Inc., Ill (n,o,q,v,w,z,bb,cc,dd,ee,ff)—Ad pp 334-5)
Kawneer Co., Mich (o,q,z)
Kinkead Industries, Inc., Ill (q,z,cc, dd)
Kirk, Morris P. & Son, Calif (w)
Korhumel Steel & Aluminum Co., Ill (o,z,bb,cc,dd,ee,ff)
Laminated Shim Co., Conn (cc)—Ad pp 340-341
Langsenkamp, F.H. Co., Ind (o,z,bb, cc,dd,ee,ff)
Light Metals, Inc., Ind (n)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Magna Mfg. Co., Inc., NJ (aa)
Magnode Products, Inc., Ohio (o)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass. (o,ee)
Malone Bronze Powder Works, Inc., NY (aa)
May, Inc., Tex (o,bb,ee)
McGregor-Michigan Corp., Mich (ee)
Mechanical Steel Tubing Corp., NY (ee)
Metal Goods Corp., Mo (o,z,bb,cc,dd, ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (bb,ff)
Metallizing Engineering Co., Inc., NY (ff)
Metals & Controls Corp., General Plate Div., Mass (v)
Metals Disintegrating Co., Inc., NJ (aa)
Morrisville Foundry Co., Inc., Vt (bb)
Murray, A.B. Co., Inc., NJ (ee)
National Aluminum Co., Ohio (bb,ee)
National Lead Co., NY (o,bb,ee)
National U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
New Jersey Aluminum Extrusion Co., Inc., NJ (bb,ee)
New Jersey Metals Co., NJ (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Olds Alloys Co., Calif (ee)
Olin Mathieson Chemical Corp., Aluminum Div., NY (n,o,q,v,w,z,aa,bb,cc, dd,ee,ff)
Ormond Mfg. Co., Inc., NJ (dd,ff)
Parker Metal Goods Co., Mass (ff)
Penn Extrusion Corp., Pa (ee)
Pioneer Aluminum, Inc., Calif (o,z,bb, cc,ee)
Precision Tube Co., Inc., Pa (ee)
Quaker State Metals Co., Pa (cc)
Reade Mfg. Co., Inc., NJ (aa)
Republic Metals Co., Inc., NY (o,v, w)
Revere Copper & Brass, Inc., NY (o,v, z,bb,cc,dd,ee)
Reynolds Aluminum Supply Co., Ga (o, z,bb,cc,ee)
Reynolds Metals Co., Va (o,q,v,w,z,aa, bb,cc,dd,ee,ff)
Rigidized Metals Corp., NY (cc,dd)
Rodney Metals, Inc., NY (dd)
Roebling's, John A. Sons Corp., NJ (dd,ff)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
Saginaw Bearing Co., Mich (o)
Sail, George Metals Co., Inc., Pa (w)
Scovill Mfg. Co., Mill Products Div., Conn (bb,cc,dd,ee,ff)—Ad pp 125-6
Security Sash & Screen Co., Mich (cc)
Sel-Rex Corp., NJ (n)
Smith-Moon Steel Co., Inc., Kan (o,z,cc)
Sonken-Galamba Corp., Kan (q,w)
Southern Aluminum Finishing Co., Inc., Ga (o,z,bb,cc,dd,ee)
Standard Metals Corp., Mass (ee)
Star Heel Plate Co., Inc., NJ (ff)
Stranahan Foil Co., Inc., NJ (v)
Sun Steel Co., Ill (cc,dd)
Techalloy Co., Inc., Pa (n,dd)
Trim Alloys, Inc., Mass (o,q,bb,dd,ee, ff)
Ullmann, Inc., Wis (o,ee)
United Screw & Bolt Corp., Ill (bb, cc,dd,ff)
United Smelting & Aluminum Co., Inc., Conn (cc,dd)
U.S. Bronze Powder Works, Inc., NJ (aa)
U.S. Extrusions Corp., NY (bb)
U.S. Gasket & Shim Co., Ohio (v)
U.S. Reduction Co., Ind (w)
United Wire & Supply Corp., RI (ee, ff)
Universal Converting Corp., Mass (o, bb,ee)
Utility Mfg. Co., Mass (bb)
Vanadium Corp. of America, NY (w)
Vulcan Rail & Construction Co., NY (o,z,ee)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., Ill (ee)
Warner Mfg. Corp., NJ (bb,ee)
Waterman Industries, Inc., Calif (o,bb, cc,dd,ee)
Werner, R.D. Co., Inc., NY (o,q,w,bb,ee)
White Metal Rolling & Stamping Co., NY (o,q,bb,ee,ff)
Whitehead Metal Products Co., Inc., NY (o,w,z,bb,cc,dd,ee,ff)
Wilder Mfg. Co., Inc., Calif (o,cc)
Wilson-Hurd Mfg. Co., Inc., Wis (cc)
Wright, Albert Screw Machine Products, Calif (bb)

Aluminum Bronze

(see Copper)

Anodes

(see specific metal)

Anodic Coatings

(see Conversion Coatings)

Asbestos

American Asbestos Textile Corp., Pa (r,s)
American Brakeblok Div., American Brake Shoe Co., Mich (r)
American Insulator Corp., Pa (r)
American Sheet Metal Works, Inc., Conn (s)
American Smelting & Refining Co., NY (s)
Asbestos Corp. of America, NJ (r,s)
Asbestos Textile Co., Inc., Ill (r,s,cc)
California Metal Enameling Co., Calif (r)
Carey, Philip Mfg. Co., Ohio (r,s,cc)
Carolina Asbestos Co., NC (r)
Chicago Gasket Co., Ill (cc)
Connell Asbestos Mfg. Co., NY (r)
Dumont Corp., Calif (r,z,bb,cc,ee)
Garlock Packing Co., NY (r,s,cc,ee)
Gatke Corp., Ill (r)
General Asbestos Gasket Mfg. Corp., Mo (r)
General Gasket, Inc., Conn (r)
Hall, C. P. Co., Ohio (s)
Johns-Manville Corp., NY (r,s,aa,cc,ee)
Keasbey & Mattison Co., Pa (s,cc,ee)
Mica Fabricating Co., NJ (s)
National Gasket & Washer Mfg. Co., Inc., NY (r,cc)
North American Asbestos Corp., Ill (r,s)
Panalyte Div., St. Regis Paper Co., NY (bb,cc)
Peerless Products Industries, Ill (r)
Philadelphia Asbestos Corp., Pa (r)
Precision Paper Tube Co., Ill (ee)
Raybestos-Manhattan, Inc., NJ (bb,cc)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (r)
Rogers Corp., Conn (cc)
Rostone Corp., Ind (r)
Ruberoid Co., NY (s)
Russell Mfg. Co., Conn (r,s)
Smith Chemical & Color Co., Inc., NY (aa)
Southern Asbestos Co., NC (r,s,ee)
Standard Asbestos Mfg. Co., Ill (r,s)
Staver Co., Inc., NY (r,cc)
Stone Paper Tube Div., Stone Straw Corp., Washington, DC (ee)
Union Asbestos & Rubber Co., Ill (r, cc,ee)
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Rubber Co., NY (s)
U.S. Stoneware Co., Ohio (r)
Vellumoid Co., Mass (r,cc)
Victor Mfg. & Gasket Co., Ill (r,cc)

Balsa Wood

(see Wood)

Bar

(see specific metal)

Beryllium

Advance Stamping Co., Mich (dd)
American Silver Co., Inc., NY (v,dd)
Babson Dow Mfg. Co., Mass (o)
Belmont Smelting & Refining Works, Inc., NY (o,aa)
Beryllium Corp., Pa (o,q,w,aa,bb)
Bridgeport Brass Co., Conn (bb,ee)
Brinkerhoff Brass & Bronze Works, Inc., NY (dd)
Brush Beryllium Co., Ohio (o,q,v,w,z,aa,bb,cc,dd,ee)—Ad p 130
Budek & Bock Spring Mfg. Co., Ill (ff)
General Plate Div., Metals & Controls Corp., Mass (v)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Hussey, C.G. & Co., Div. of Copper Range Co., Pa (aa)
Inshield Die & Stamping Co., Ohio (dd)
Instrument Specialties Co., Inc., NJ (bb,dd,ff)
Lundquist Tool & Mfg. Co., Inc., Mass. (cc,dd)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (dd,ff)
Mallory, P.R. & Co., Inc., Ind (bb, dd,ff)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Olds Alloys Co., Calif (ee)
Oregon Metallurgical Corp., Ore (w)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (bb,dd,ff)
Sel-Rex Corp., NJ (n)
Westinghouse Electric Corp., Pa (o,q, v,w,z,bb,cc,dd,ee)

Beryllium Copper

(see Copper)

Billets

(see specific metal)

Bismuth and Its Alloys

Alpha Metals, Inc., NJ (o,q,v,bb,cc,dd)
American Metal Climax, Inc., NY (o,w,aa)
Anaconda Aluminum Co., Sub. of Anaconda Co., NY (o)
Belmont Smelting & Refining Works, Inc., NY (n,o,w,aa)
Cerro de Pasco Sales Corp., NY (w)—Ad p 133
Division Lead Co., Ill (o,ff)
Empire Metal Co., NY (n,o,q,w,bb,ff)

Federated Metals Div., American Smelting & Refining Co., NY (o,w)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Peerless Alloy Co., Colo (o,w)
Republic Metals Co., Inc., NY (o,w)
River Smelting & Refining Co., Ohio (o)
Sel-Rex Corp., NJ (n)
U.S. Smelting, Refining & Mining Co., NY (w,dd)
Westinghouse Electric Corp., Pa (o,q, v,w,z,bb,cc,dd,ee)

Borides

(see Refractories)

Brass

(see Copper)

Brazing Alloys

Abalon Precision Mfg. Corp., NY
All-State Welding Alloys Co., Inc., NY
American Platinum & Silver Div., Engelhard Industries, Inc., NY —Ad p 395
American Products Corp., Ill
American Silver Co., NY
Belmont Smelting & Refining Works, Inc., NY
Burgess-Norton Mfg. Co., Ill
Crucible Steel Co. of America, Pa
Dormont Mfg. Co., Pa
Electric Materials Co., Pa
Eutectic Welding Alloys Corp., NY
Fairstrom Co., NJ
General Findings & Supply Co., Industrial Div., Mass
Glidden Co., Chemicals-Pigments-Metals Div., Md
Goldsmith Bros. Smelting & Refining Co., Ill
Handy & Harman, NY —Ad p 399
Hayden Wire Works, Inc., Mass
Inland Mfg. Co., Neb
International Nickel Co., Inc., NY
Kenmore Machine Products, Inc., NY
Kinkead Industries, Inc., Ill
Kling Metal Spinning & Stamping Co., NY
Kwikset Powdered Metal Products, Calif
Lincoln Iron Works, Vt
Lucas-Milhaupt Engineering Co., Wis
Machine Products Corp., Ohio
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass.
Mansol Ceramics Co., NJ
McDowell Mfg. Co., Pa
Revere Copper & Brass, Inc., NY
Sall, George Metals Co., Inc., Pa
United Wire & Supply Corp., RI
Vanadium-Alloys Steel Co., Pa
Victor Equipment Co., Calif
Wall Colmonoy Corp., Stainless Process Div., Mich —Ad p 402
Waterman Industries, Inc., Calif
West Haven Foundry Co., Conn
Western Gold & Platinum Co., Calif
Whitehead Metal Products Co., Inc., NY

Bronze

(see Copper)

Buna N Rubber

(see Acrylonitrile-Butadiene Rubber)

Butadiene Styrene

(see Styrene Butadiene)

Butyl Rubber

(see Isoprene-Isobutylene Rubber)

Butyrate

(see Cellulose Acetate Butyrate)

Cadmium

Alpha Metals, Inc., NJ (o,q,v,bb,cc,dd)
American Metal Climax, Inc., NY (n,o,w,aa,bb)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,q,w)
American Zinc Sales Co., Mo (n,o,z)
Anaconda Aluminum Co., Sub. of Anaconda Co., NY (o)
Anchor Metal Co., Inc., NY (w)
Auld, D.L. Co., Ohio (n)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,z,aa,cc)
Bunker Hill Co., Calif (n,o)
Cerro de Pasco Sales Corp., NY (z,bb)
Division Lead Co., Ill (v,cc)
Eagle-Picher Co., Ohio (q)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting & Refining Co., NY (o,w)
Goldsmith Bros. Smelting & Refining Co., Ill (o,w)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hull, R.O. & Co., Inc., Ohio (n)
International Minerals & Metals Corp., NY (w)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (dd,ee,ff)
McGean Chemical Co., Ohio (n,dd)
Metals Disintegrating Co., Inc., NJ (aa)
Modern Plating Corp., Ill (n)
New Jersey Metals Co., NJ (n)
New Jersey Zinc Co., NY (n)
Octagon Process, Inc., NY (n,o,q,w,z, bb,cc,dd)
Peerless Alloy Co., Colo (o,w)
Republic Metals Co., Inc., NY (n,o,w)
River Smelting & Refining Co., Ohio (w)
St. Joseph Lead Co., NY (n,o,w)
Sel-Rex Corp., NJ (n)
Stevens, Frederic B., Inc., Mich (n)
Triangle Conduit & Cable Co., Inc., NJ (ff)
Udylite Corp., Mich (n,bb,cc,ff)
U.S. Smelting, Refining & Mining Co., NY (o,w,bb)

Calorized Coatings

(see Diffusion Coatings)

Carbides

(see Refractories)

Carbon, Graphite

Becker Bros. Carbon Co., Ill (r,z,aa, bb,cc,ee)
Black Bear Co., Inc., NY (aa)
Blaco Mfg. Co., Ohio (aa)
Dixon, Joseph Crucible Co., NJ (z, aa,bb)
Electro Chemical Engineering & Mfg. Co., Pa (r)
Gibson Electric Co., Pa (r,aa)
Graphite Metallizing Corp., NY (r)
Graphite Specialties Corp., NY (r,bb,ee)—Ad p 252
Heil Process Equipment Corp., Ohio (r)
Henrite Products Corp., Ohio (r)
Hofford Varnish Co., Inc., NJ (r)
Industrial Tectonics, Inc., Mich (r)
Markal Co., Ill (z)
Metallized Carbon Co., NY (r)
Morganite, Inc., NY (r,bb,ee)
National Carbon Div., Union Carbide Corp., NY (r,aa,bb,ee)
Ohio Carbon Co., Ohio (r,z,aa,bb,cc,ee)—Ad p 340
Pure Carbon Co., Inc., Pa (bb)
Russell Mfg. Co., Conn (r,s)
St. Marys Carbon Co., Pa (r,z)
Servwell Products Co., Ohio (aa)
Smith Chemical & Color Co., Inc., NY (aa)
Speer Carbon Co., Pa (r)
Stackpole Carbon Co., Pa (r,z,bb,ee)—Ad p 248
Standard Asbestos Mfg. Co., Ill (s,cc, ee)
United Carbon Products Co., Mich (r, z,aa,bb,cc,ee)
U.S. Graphite Co., Div. of Wickes Corp., Mich (r,bb,cc)

Carbon Steel

(see Steel)

Casting Resins

(see specific plastic or rubber)

Castings, Centrifugal

Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
All Metals Precision Casting Corp., NY (a,b,g)
Allegheny Ludlum Steel Corp., Pa (g)
Alloy Precision Castings Co., Ohio (a, b,c,e,f)
American Brake Shoe Co., NY (a,b,j)
American Cast Iron Pipe Co., Ala (a,c,f,g)
American Crucible Products Co., Ohio (b)
Ampco Metal, Inc., Wis (b)
Asco Sintering Corp., Calif (a,b)
Baldwin-Lima-Hamilton Corp., Pa (a, b,f)
Bendix Foundries, NJ (a,e)
Blaw-Knox Co., Pa (f,g)
Buckeye Brass & Mfg. Co., Ohio (b)
Bunting Brass & Bronze Co., Ohio (b)
Calorizing Co., Pa (f,g)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c,g)
Centrifugal Casting Machine Co., Okla (a,b)
Centrifugally Cast Products Div., Shenango Furnace Co., Ohio (b,c,f)
Centr-O-Cast & Engineering Co., Mich (a)
Cooper Alloy Corp., NJ (g)—Ad p 353
Copper & Brass Sales Inc., Mich (b)
Crucible Steel Co. of America, Pa (c,f,g,h)
Curtiss-Wright Corp., Metal Processing Div., NY (g)
Cyril Bath Co., Ohio (g)
Dayton Foundry, Calif (c)
Duraloy Co., Pa (f,g)—Ad p 359
Electric Steel Foundry Co., Ore (f,g,h)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Florence Pipe Foundry & Machine Co., NJ (c)
Frasse, Peter A. & Co., Inc., NY (g)
General Alloys Co., Mass (f)
General Electric Co., Foundry Dept., NY (a,b)
Hi-Grade Alloy Corp., Ill (d,j)
Hughes Tool Co., Tex (g)
Humphrey Castings, Inc., Calif (a,b,f, g)
Illinois Precise Casting Co., Ill (a, b,f,g)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

International Nickel Co., Inc., NY
(f)
Janney Cylinder Co., Pa (a,b,c,f)
Johnson Bronze, Pa (b)
Kay-Brunner Steel Products, Inc., Calif (g)
Lebanon Steel Foundry, Pa (g)
Linton Precision Casting Co., Ind (a, b,c,f,g,j)
Mallory, P.R. & Co., Inc., Ind (b)
McCarter Iron Works, Inc., Pa (c,g)
Meehanite Metal Corp., NY (c)
Metal Goods Corp., Mo (a,b,c,f)
Metals Processing Div., Curtiss-Wright Corp., NY (f,g)
Milwaukee Aluminum & Brass Foundry, Wis (a,b)
Misco Precision Casting Co., Mich (c, f,g)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Lead Co., NY (b,d)
National Lead Construction Co., Inc., NJ (l)
Ohio Steel Foundry Co., Ohio (f)
Olds Alloy Co., Calif (a,b,d,f)
Oregon Metallurgical Corp., Ore (h)
Precision Founders, Inc., Calif (a,b,c,f, g,j)
Precision Metalsmiths, Inc., Ohio (a, b,c,d,f,g)
Quality Electric Steel Castings, Inc., Tex (g)

Sandusky Foundry & Machine Co., Ohio
(b,f,g)—Ad p 345
Schilling Bronze Co., NY (b,d,f,j)
Sheller Mfg. Corp., Mich (j)

Sorbo-Mat Process Engineers, Mo
(c)—Ad p 355
Stainless Foundry & Engineering, Inc., Wis (f,g)
State Foundry & Machine Co., Wis (c)
Staver Co., Inc., NY (d)
Stoody Co., Calif (d)
Swayne-Robinson & Co., Ind (a,c)
Terre Haute Bronze & Brass Foundry, Ind (b)
Thys Co., Calif (a,b,c,f,g)
True Alloys, Inc., Mich (a,b,d,f,j)
U.S. Pipe & Foundry Co., Ala (c,g)
Uniworld Research Corp. of America, Ohio (c)
Utica Drop Forge & Tool Co., NY (f, g)
Vollrath Co., Wis (g)
Weatherhead Co., Ind (j)
West Steel Casting Co., Ohio (f)
Whitehead Metal Products Co., Inc., NY (f)
Winters Foundry & Machine Co., Inc., Ohio (a,b)
Wisconsin Centrifugal Foundry, Inc., Wis (a,b,d,f,g)

Castings, Die

A & A Die Casting Co., Calif (a,d,j)
Able Tool & Engineering Co., Ill (a,j)
Accurate Metal Weather Strip Co., Inc., NY (j)
Admiral Die Castings Div., Portable Electric Tools, Inc., Ill (a,j)
Advance Pressure Castings, Inc., NY (a,j)
Advance Tool & Die Casting Co., Wis (a,j)

Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
(a,j)- Ad p 344
Allen-Stevens Corp., NY (j)

Aluminum Co. of America, Pa
(a)—Ad p 331
Ambrit Industries, Inc., Calif (a,d,j)
American Aluminum Castings Co., NJ (a)

American Crucible Products Co., Ohio
(b)
American Foundries Co., Mich (c)
American Foundry & Machine Div., Elmco Corp., Utah (g)
Auel Industries, Pa (j)
Auld, D.L. Co., Ohio (a,j)
Aurora Metal Co., Ill (b)
Badger Die Casting Corp., Wis (a,j)

Belmont Smelting & Refining Works, Inc., NY
(a,d)
Beloit Foundry Co., Ill (c)
Bendix Foundries, NJ (a,e)
Briel Industries, Inc., Ind (a)
Centrifugal Casting Machine Co., Okla (a)
Centr-O-Cast & Engineering Co., Mich (a)
Century Die Casting Co., Ill (a,j)
Chicago White Metal Casting, Inc., Ill (a,j)
Cincinnati Foundry Co., Ohio (c)
Comet Metal Products Co., Inc., NY (j)
Conneaut Die Casting Co., Ohio (a,j)
Continental Die Casting Corp., Mich (j)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa (c, f,g)
Davis Products Corp., NY (j)
Dayton Bronze Bearing Co., Ohio (a,j)
Dayton Malleable Iron Co., Ohio (a)
Die Cast Products, Inc., Calif (a,j)
Diecast Corp., Mich (a,j)
Division Lead Co., Ill (d)
Doehler-Jarvis Corp., Div. of National Lead Co., Ohio (a,b,e,j)

Dollin Corp., NJ
(a,d,j)—Ad p 350
Dow Chemical Co., Magnesium Div., Mich (e)
Duane Specialties, Ltd., NJ (j)
Du-Wel Metal Products, Inc., Mich (a,j)
Ehrsam, J.B. & Sons Mfg. Co., Kan (c)
Electric Auto-Lite Co., Ohio (a,j)
Federal Die Casting Co., Ill (a)
Foster Aluminum Alloy Products Corp., NY (a)
General Electric Co., Foundry Dept., NY (b)
General Motors Corp., Fabricast Div., Ind (a)
Grammes, L.F. & Sons, Inc., Pa (j)
Grand Rapids Brass Co., Mich (j)
Grey, C.M. Industries, Inc., NJ (a,j)

Gries Reproducer Corp., NY
(j)
Hamilton Die Cast, Inc., Ohio (a,j)
Hampden Brass & Aluminum Co., Mass (a,j)
Harbot Die Casting Corp., NJ (a)
Hardy Mfg. Corp., Ind (a,j)
Harvey Aluminum Div., Harvey Machine Co., Inc., Calif (a,j)
Harvill Corp., Calif (a,b,e,j)
Hercules Fastener Co., Ill (j)
Hica, Inc., La (g)
Hilfinger Corp., Ohio (j)
Hoover Co., Die Casting Div., Ohio (a, j)
Humphrey Castings, Inc., Calif (a)
Jersey Plastic & Die Casting Co., NJ (a,j)

Kaiser Aluminum & Chemical Sales Inc., Ill
(a)
Kamin Die Casting & Mfg. Co., Ill (a,j)
Kent Castings Corp., Mich (j)
King-Seeley Corp., Mich (j)
Krone, Paul Die Casting Co., Ill (a,j)
La France Precision Casting Co., Pa (j)
Lake Erie Foundry Co., NY (c)
Lester Castings, Inc., Ohio (a,j)
Light Metals, Inc., Ind (a,e)
Litemetal Dicast, Inc., Mich (e)
Littlestown Hardware & Foundry Co., Inc., Pa (a)
Livingston-Tyler Products, Ohio (j)
Madison Kipp Corp., Wis (a,j)
Magline Inc., Mich (a,e)
Mallory, P.R. & Co., Inc., Ind (b,h)
Manor Die Cast Corp., Ohio (a)
Meehanite Metal Corp., NY (c)
Meta-Mold Aluminum Co., Sub. of Dayton Malleable Iron Co., Wis (a,e)
Milwaukee Die Casting Co., Wis (a,d,j)
Missouri Diecasting Co., Mo (a,j)
Model Brass Co., Inc., Ill (a,b)
Moldcast Products, Inc., NJ (a)

Monarch Aluminum Mfg. Co., Ohio
(a,j)—Ad p 336
Monarch Tool & Mfg. Co., Ky (j)
Mt. Vernon Die Casting Corp., Conn (a)
National Lead Co., NY (a,b,d,e,j)
National Lead Construction Co., Inc., NJ (d)
National Malleable & Steel Castings Co., Ohio (j)
National Supply Co., Industrial Products Div., Calif (g)

New Jersey Zinc Co., NY
(j)—Ad p 325
New Products Corp., Mich (a,e)
Newton-New Haven Co., Conn (a,j)
Norgren-Stemac, Inc., Colo (j)
Olderman Mfg. Corp., Conn (j)
Paragon Die Casting Co., Ill (a,j)
Paramount Die Casting Co., Mich (a, e,j)

Parker White Metal Co., Pa.
(a,d,f,j)—Ad p 333
Peasley Products, Inc., Conn (a,j)
Phoenix Die Casting Co., NY (a,j)
Pittsburgh Die & Casting Co., Pa (a,j)
Porter, H.K., Inc., Forge & Fittings Div., Ohio (a,j)
Rangers Die Casting Co., Calif (a,j)
Republic Die Casting Co., Mo (a,j)
Republic Metals Co., Inc., NY (d)
Rupert Diecasting Co., Mo (a,j)
St. Louis Diecasting Corp., Mo (a,j)
St. Marys Foundry Co., Ohio (c)
Sargent & Greenleaf, Inc., NY (a,j)
Schilling Bronze Co., NY (a,b,d,f,j)
Schneider, Bowman Co., Inc., Pa (c)
Schultz Die Casting Co., Ohio (a,j)
Southern Metal Products Co., La (a)
Star Heel Plate Co., Inc., NJ (a,j)
Staver Co., Inc., NY (d)
Stella Products Corp., NJ (j)
Sterling Die Casting Co., NY (a,j)
Stewart-Warner Corp., Stewart Die Casting Div., Ill (a,e,j)
Stuart Foundry Co., Mich (c)
Superior Die Casting Co., Ohio (a,j)
Thompson Products, Light Metals Div., Ohio (a)
Titan Metal Mfg. Co., Pa (b)
Tower Grove Foundry, Mo (c)
Twin City Die Casting Co., Minn (a, d,j)
Veeder-Root, Inc., Conn (j)
Vulcan Rail & Construction Co., NY (a,c,g)
Weber-Knapp Co., NY (a)
West Irving Die Casting Co., Ill (a)
Westland Die Casting, Inc., Calif (a,j)
Wheaton Die Casting Corp., NJ (a,j)

Castings, Investment

All Metals Precision Casting Corp., NY (a,b,g)
Alloy Precision Castings Co., Ohio (a, b,c,e,f,g)
Arwood Precision Castings Corp., NY (a,b,e,g)
Austenal, Inc., NY (a,c,f,g)
Bone Engineering Corp., Calif (a,b,f,g)
Buckeye Brass & Mfg. Co., Ohio (a, b,c,g)
Budd-Stanley Co., Inc., NY (a,b,e,f,h,j)

Casting Engineers, Inc., Ill
(a,b,c,f,g)—Ad p 332
Centrifugal Casting Co., NY (a,b,e,f, h,j)
Chrysler Corp., Mich (a,b,c,e,f,g,h,j)
Crucible Steel Co. of America, Pa (c,f,g)
Eaton Mfg. Co., Foundry Div., Mich (c)
Electric Steel Foundry Co., Ore (h)
Electronicast Div., Nilsen Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Engineered Precision Casting Co., NJ (a,b,c,f,g)
General Electric Co., Foundry Dept., NY (a,b,c,e,f,g,h,j)
General Motors Corp., Fabricast Div., Ind (a,f)
Gray-Syracuse, Inc., NY (a,b,c,f,g)
Harcast Co., Inc., Pa (a,b,c,f,g)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f,g)
Hawkridge Bros. Co., Mass (a,b,c,e,f, g,h,j)
Hica, Inc., La (f,g)
Hitchiner Mfg. Co., Inc., NH (a,b,c, f,g)
Howard Foundry Co., Ill (a,b,c,f,g)
Humphrey Castings, Inc., Calif (a,b,f,g)
Illinois Precise Casting Co., Ill (a,b, f,g)

International Nickel Co., Inc., NY
(f)
Investment Casting Co., NJ (a,b,c,f,g)
Jelrus Precision Casting Corp., NY (a,b,c,e,f,g,h,j)
Joseff-Hollywood Co., Calif (a,b,c,g)
Kolcast Industries Div., Thompson Products, Inc., Ohio (a,c,f,g)
Lawrence Laboratory, Calif (a,b,e)
Lebanon Steel Foundry, Pa (g)
Linton Precision Casting Co., Ind (a,b,c,f,g,j)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Lynn Casting Corp., Calif (a,b,d)
Meehanite Metal Corp., NY (c)
Mercast Mfg. Corp., Calif (a,b,c,e,f,g)
Metal Goods Corp., Tex (f)
Midwest Precision Castings Co., Ohio (a,b,c,f,g)
Misco Precision Casting Co., Mich (c,f,g)
National Precision Casting Corp., Div. of Beryllium Corp., Pa (a,b,c,f,g)
Omni-Metal Castings, Inc., NY (a, b,c,f,g)
Picco, Inc., Calif (a,b,c,f,g)
Precision Castparts Corp., Ore (a,b, f,g)
Precision Founders, Inc., Calif (a, b,c,f,g,j)
Precision Metalsmiths, Inc., Ohio (a, b,c,d,f,g)
Rausch Mfg. Co., Minn (a,b)
Rode, Inc., Mass (a,b)
Rolle Mfg. Co., Pa (a,b,e,g)
Solon Foundry, Inc., Ohio (a,e)
Star Heel Plate Co., Inc., NJ (a,b)
Staver Co., Inc., NY (d)
Thompson, K.W. Tool Co., NY (a,b, c,e,f,g,h,j)
Thys Co., Calif (a,b,c,f,g)
United Shoe Machinery Corp., Mass (g)
Uniworld Research Corp. of America, Ohio (c)

Wall Colmonoy Corp., Stainless Process Div., Mich
(c,f)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Whitehead Metal Products Co., Inc. NY (f)
York Casting, Inc., NY (a,b,c,e,f,g, h,j)
Z & H Mfg. Co., NY (a,b,c,e,f,g,h,j)

Castings, Nonmetallic

(plastics and rubber)
A & A Die Casting Co., Calif (k)
Ace Plastic Co., NY (l)

Acushnet Process Co., Mass (m)—Ad p 220
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (k,l)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (1)
Auburn Plastic Engineering, Ill (k)
Automotive Rubber Co., Inc., Mich (m)
Biggs, Carl H. Co., Inc., Calif (k,l)
Boonton, Molding Co., NJ (k,l,m)
Buckeye Molding Co., Ohio (k)
Cadillac Plastic & Chemical Co., Mich (k)
Campro Co., Ohio (k)
Cast Optics Corp., NJ (k,l)
Ceilcote Co., Ohio (l)
Chemical Development Corp., Mass (l)
Conneaut Rubber & Plastics Co., Ohio (k)
Disogrin Industries, Inc., NY (m)
Douglas & Sturgess, Calif (l,m)
Eby, Hugh H. Co., Pa (k,l)
Electric Auto-Lite Co., Ohio (k,l)
Eljay Corp., Md (l)
Emerson & Cuming, Inc., Mass (k,l,m)
Foss Mfg. Co., Plastics Div., Id (l)
Fry Plastics Co., Calif (k,l)
General Mills, Inc., Chemical Div., Ill (k,l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Grimes Mfg. Co., Plastic Research Products, Ohio (l)
Hays Mfg. Co., Pa (l)
Houghton Laboratories, Inc., NY (l)
Kerr, R.W. Plastic Co., Neb (k,l,m)
Kurz Kasch, Inc., Ohio (l)
Marblette Corp., NY (l)
Mechanical Rubber Products Co., NY (l)
Minnesota Rubber Co., Minn (l,m)
Minnesota Rubber & Gasket Co., Minn (k,m)
Munray Products Div., Fanner Mfg. Co., Ohio (k,m)
New England Tape Co., Inc., Mass (l)
Pyrosil, Inc., Ohio (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastics, Inc., Mich (l)
Riverside Plastics Corp., NY (l)
Robot Devices, Inc., Va (l)
Sewell Mfg. Co., Mich (l)
Sierra Electronic Corp., Calif (j)
Superior Plastics, Inc., Ill (k)
Sylvania Electric Products, Inc., Parts Div., Pa (k,l)
U.S. Stoneware Co., Ohio (k)

Castings, Permanent Mold

A C F Industries, Inc., NY (e)
Abco Aluminum & Brass Works, Tex (a,d)
Acme Aluminum Foundry Co., Ill (a)
Advance Aluminum Castings Corp., Ill (a)
Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
Aluminum Alloys Corp., Mich (a)
Aluminum Co. of America, Pa (a)
Aluminum Casting & Engineering Co., Wis (a,j)
Aluminum Industries, Inc., Ohio (a)
Aluminum Permanent Mold Co., Mich (a)—Ad p 354
American Aluminum Castings Co., NJ (a)
American Brake Shoe Co., NY (a,b,j)
American Metal Climax, Inc., NY (b)
Apex Steel Corp., Ltd., Calif (g)
Baldt Anchor, Chain & Forge Div., Boston Metals Co., Pa (a,b)
Baldwin-Lima-Hamilton Corp., Pa (a, b,f)
Belmont Smelting & Refining Works, Inc., NY (a,d,j)
Bendix Foundries, NJ (a,e)
Bohn Aluminum & Brass Corp., Mich (a)
Bridgeport Brass Co., Conn (a)
Briggs-Shaffner Co., NC (a)
Bronze & Steel Die Casting Co., Ill (b)
Buckeye Brass & Mfg. Co., Ohio (a, b,j)
Bunker Hill Co., Calif (d,j)
Bunting Brass & Bronze Co., Ohio (b)
Calumet Div., Calumet & Hecla, Inc., Mich (c)
Centrifugal Casting Machine Co., Okla (a)
Centr-O-Cast & Engineering Co., Mich (a)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Cochrane Foundry, Inc., Pa (a,b,j)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa (c,f,g)
Davis Products Corp., NY (j)
Dayton Malleable Iron Co., Ohio (a)
Derby Castings Co., Conn (a)
Dirilyte Co. of America, Inc., Ind (b)
Division Lead Co., Ill (d)
Dixie Bronze Co., Ala (a,b,f)
Dostal Foundry & Machine Co., Mich (c)
Dow Chemical Co., Magnesium Div., Mich (e)
Eaton Mfg. Co., Foundry Div., Mich (c)
Ehrsam, J.B. & Sons Mfg. Co., Kan (c)
Electric Steel Foundry Co., Ore (f,g)
Enterprise Wheel & Car Corp., Va (a)
Est Co., Inc., Wis (a,e)
Exalco Mfg. Co., Ohio (a)—Ad p 344
Fairfield Aluminum Casting Co., Iowa (a)
Flynn, Michael Mfg. Co., Pa (a)
General Aluminum Mfg. Co., Ohio (a,e)
General Electric Co., Foundry Dept., NY (c)
General Motors Corp., Fabricast Div., Ind (a)
Gillett & Eaton, Inc., Minn (a,c)
Hampden Brass & Aluminum Co., Mass (a)
Harvill Corp., Calif (a,e)
Howard Foundry Co., Ill (a,e)
Humphrey Castings, Inc., Calif (a)
Johnson Bronze Co., Pa (b)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Lebanon Steel Foundry, Pa (g)
Light Metals, Inc., Ind (a,e)
Littlestown Hardware & Foundry Co., Inc., Pa (a)
Magline, Inc., Mich (a,e)
Mallory, P.R. & Co., Inc., Ind (h)
Manco Products, Inc., Mich (b)
Manor Die Cast Corp., Ohio (a)
Mansfield Brass & Aluminum Corp., Ohio (a)
Marshall Car & Wheel Foundry Co., Inc., Tex (c)
McLanahan & Stone Corp., Pa (c)
Meehanite Metal Corp., NY (c)
Metal Mold Magnesium Corp., Wis (e)
Meta-Mold Aluminum Co., Sub of Dayton Malleable Iron Co., Wis (a,e)
Moldcast Products, Inc., NJ (a)
Monarch Aluminum Mfg. Co., Ohio (a)—Ad p 336
Morse, Fred W. Co., RI (a,j)
National Aluminum Mfg. Co., Ill (a)
National Lead Construction Co., Inc., NJ (d)
Olds Alloys Co., Calif (b,d,f)
Oregon Metallurgical Corp., Ore (h)
Parker, Charles Co., Conn (a,j)
Peasley Products, Inc., Conn (a,j)
Permold Co., Ohio (a)
Rolle Mfg. Co., Pa (a,e)
Schilling Bronze Co., NY (a,b,d,f,j)
Schmeller Aluminum Foundry Co., Ohio (a)
Skookum Co., Inc., Ore (g)
Sorbo-Mat Process Engineers, Mo (c)—Ad p 355
Standard Magnesium Corp., Okla (e)
Star Heel Plate Co., Inc., NJ (a,b)
Staver Co., Inc., NY (d)
Sterling Aluminum Products, Inc., Mo (a)
Stewart-Warner Corp., Stewart Die Casting Div., Ill (a)
Superb Light Alloys, Inc., NY (a,e)
Texas Foundries, Inc., Tex (a,g)
Thompson Products, Light Metals Div., Ohio (a)
True Alloys, Inc., Mich (a,b,d,j)
Universal Castings Corp., Ill (a,b)
Vulcan Rail & Construction Co., NY (a,c)
Waterman Industries, Inc., Calif (a)
Wellman Bronze & Aluminum Co., Ohio (a,e)
Williams, A.C. Co., Ohio (e)
Winters Foundry & Machine Co., Inc., Ohio (a)
Wisconsin Aluminum Foundry Co., Inc., Wis (a,b)

Castings, Plaster Mold

Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
All Metals Precision Casting Corp., NY (a,b)
Alloy Precision Castings Co., Ohio (a, b,c,e,f,g)
Aluminum Co. of America, Pa (a)
Atlantic Casting Engineering Corp., NJ (a,b)—Ad p 346
Bean, Morris & Co., Ohio (a)—Ad p 364
Beloit Foundry Co., Ill (c)
Bendix Foundries, NJ (a,e)
Curtiss-Wright Corp., NY (g)
Derby Castings Co., Conn (a)
Ehrsam, J.B. & Sons Mfg. Co., Kan (c)
General Motors Corp., Fabricast Div., Ind (a)
Hampden Brass & Aluminum Co., Mass (a)
Humphrey Castings, Inc., Calif (a)
Lebanon Steel Foundry, Pa (g)
Lincoln Foundry Corp., Calif (c)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Meehanite Metal Corp., NY (c)
Mercast Mfg. Corp., Calif (a,b,c,e, f,g)
Ohio Precision Castings, Inc., Ohio (a,b,f)
Olderman Mfg. Corp., Conn (b)
Ross-Meehan Foundries, Tenn (c,g)
Schilling Bronze Co., NY (a,b,d,f,j)
Schneider, Bowman Co., Inc., Pa (c)
Searjeant Metal Products, Inc., NJ (a,c)
Solon Foundry, Inc., Ohio (a,e)
Sorbo-Mat Process Engineers, Mo (c)—Ad p 355
True Alloys, Inc., Mich (a,b)
Universal Castings Corp., Ill (a,b)
Wayne Foundry & Stamping Co., Mich (j)
Western Iron & Foundry Co., Inc., Kan (c)

Castings, Sand

Abco Aluminum & Brass Works, Tex (a,b,d,f,j)
Acco Malleable Casting Div., American Chain & Cable Co., Inc., Pa (c)
Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa (b, c,g)
Acme Aluminum Foundry Co., Ill (a)
Acme Foundry & Machine Co., Kan (c)
Acme Foundry & Machine Co., Okla (c)
Advance Foundry Co., Ohio (c)
Aelco Foundries, Inc., Wis (a,b,d,e, f,g)
Albany Car Wheel Co., Inc., NY (c)
Albert Lea Foundry Co., Minn (c)
Albion Malleable Iron Co., Mich (c)
Alcasco Foundry, Ill (a,b)
Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
Allegheny Foundry Co., Pa (c)
Allegheny Ludlum Steel Corp., Pa (g)
Allied Steel Castings Co., Ill (g)
Alloy Cast Steel Co., Ohio (g)
Alloy Steel Casting Co., Pa (f,g)
Almont Mfg. Co., Mich (c)
Alten Foundry & Machine Works, Inc., Ohio (c)
Aluminum Alloys Corp., Mich (a)
Aluminum Co. of America, Pa (a,e)
Aluminum Industries, Inc., Ohio (a)
Aluminum Permanent Mold Co., Mich (a)
Amalgamated Steel Corp., Ohio (g)
American Aluminum Casting Co., NJ (a)
American Brake Shoe Co., NY (a, b,j)
American Car & Foundry Div., ACF Industries, Inc., NY (c)
American Cast Iron Pipe Co., Ala (c,f,g)
American Crucible Products Co., Ohio (b)
American Foundries Co., Mich (c)
American Laundry Machinery Co., NY (c)
American Light Alloys, Inc., NJ (a, e)
American Manganese Steel Div., American Brake Shoe Co., Ill (g)
American Metal Climax, Inc., NY (b)
American Sanitary Mfg. Co., Ill (b)
American Steel Foundries, Ind (g)
American Steel Foundries, Ill (g)
Ampco Metal, Inc., Wis (b)
Apex Foundry, Inc., Mich (c,e,f)
Apex Steel Corp., Ltd., Calif (g)
Arkansas Foundry Co., Ark (c)
Arneson Foundry Co., Wis (c,g)
Arnold Engineering Co., Ill (a,c,f)
Arzt, T.L. Foundry Co., Ill (c)
Atlantic Foundry Co., Ohio (c,g)
Atlantic Steel Castings Co., Pa (g)
Atlas Brass Foundry, Calif (b)
Atlas Foundry Co., Ohio (c)
Atlas Foundry & Machine Co., Wash (c,g)
Atlas Foundry & Mfg. Co., Calif (c)
Auto Specialties Mfg. Co., Mich (c)

Letters in ( ) indicate materials and forms—turn page for key

Badger Malleable & Mfg. Co., Wis (c)
Banner Iron Works, Mo (c)
Barnard Foundry Co., Inc., Mass (b)
Barnett Foundry & Machine Co., NJ (c)
Baxter Foundry & Machine Works, Inc., Id (a,b,c)
Bay City Electric Steel Casting Co., Mich (g)
Bay City Foundry Co., Mich (c)
Bay State Tool & Machine Co., Mass (g)
Bean, Morris & Co., Ohio (c)—Ad p 364
Bearium Metals Corp., NY (b)
Beaver Valley Alloy Foundry Co., Pa (c,g)
Belcher Malleable Iron Co., Mass (c)
Bellaire Stove Co., Ohio (c)
Belle City Malleable Iron Co., Wis (c)
Beloit Foundry Co., Ill (c)
Bendix Foundries, NJ (a,e)
Beryllium Corp., Pa (b)
Bethlehem Steel Co., Pa (c,g)
Bierman-Everett Foundry Co., NJ (a, b,c)
Bignall Co., NY (c)
Black-Clawson Co., Ohio (c)
Blackmer Pump Co., Ohio (c)
Blaw-Knox Co., Pa (f,g)
Bohn Aluminum & Brass Corp., Mich (a)
Bond, Charles Co., Pa (c)
Bonnot Co., Ohio (c)
Bridgeport Brass Co., Conn (a,b,c)
Briggs-Shaffner Co., NC (a,c)
Brinkerhoff Brass & Bronze Works, Inc., NY (a)
Bruce Foundry and Mfg. Co., Mich (c)
Buckeye Iron & Brass Works, Ohio (a,b)
Bunting Brass & Bronze Co., Ohio (b)
Butler Engine & Foundry Co., Inc., Pa (a,b,c)
Cadillac Malleable Iron Co., Mich (c)
Calorizing Co., Pa (f,g)
Calumet Div., Calumet & Hecla, Inc., Mich (c)
Calumet Steel Castings Corp., Ind (g)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c,g)
Canton Malleable Iron Co., Ohio (c)
Carondelet Foundry Co., Mo (c,f)
Case, J.I. Co., Wis (c)
Casting Service Corp. of Michigan, Mich (c)
Chain Belt Co., Wis (c)
Chambersburg Engineering Co., Pa (c)
Chase Brass & Copper Co., Conn (b)
Chattanooga Aluminum Foundry, Inc., Tenn (a)
Chicago Aluminum Castings, Ill (a)
Chicago Hardware Foundry Co., Ill (a,b,c)
Chicago Malleable Castings Co., Ill (c)
Cincinnati Foundry Co., Ohio (c)
Clark Bros. Co. Div., Dresser Operations, Inc., NY (c)
Clarksville Foundry & Machine Works, Tenn (c)
Cleveland Foundry & Mfg. Co., Inc., Tenn (c)
Clinton Metal Products Co., Ohio (a)
Cochrane Foundry, Inc., Pa (a,b,j)
Columbian Bronze Corp., NY (a,b,j)
Columbiana Pump Co., Ohio (c)
Commercial Iron Works, Calif (c)
Commercial Steel Casting Co., Ohio (g)
Compton Foundry, Calif (c)
Continental Gin Co., Ala (c)
Cooper Alloy Corp., NJ (g,h)—Ad p 353
Cooper-Bessemer Corp., Ohio (c)
Copper & Brass Sales, Inc., Mich (a,b)
Crawford & Doherty Foundry Co., Ore (c)
Crown Non-Ferrous Foundry, Inc., Pa (a,b,f)
Crucible Steel Co. of America, Pa (c,g)
Crucible Steel Casting Co., Pa (g)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g)
Dalton Foundries, Inc., Ind (c)
Darling Valve & Mfg. Co., Pa (c)
Dayton Bronze Bearing Co., Ohio (a,b)
Dayton Foundry, Calif (c)
Dayton Malleable Iron Co., Ohio (a, c)
Decatur Casting Co., Ind (c)
Decrow Engineering Corp., NY (a,b)
De Laval Steam Turbine Co., NJ (c)
Derby Castings Co., Conn (a,b)
De Sanno Foundry & Machine Co., Calif (a,b)
Detroit Brass & Malleable Co., Mich (c)
Deuscher, H.P. Co., Ohio (c)
Dexter Foundry Div., Philco Corp., Iowa (c)
Dirilyte Co. of America, Inc., Ind (b)
Dixie Bronze Co., Ala (a,b,f)
Dormont Mfg. Co., Pa (b)
Dow Chemical Co., Magnesium Div. Mich (e)
Driver-Harris Co., NJ (f)
Duluth Brass Works Co., Minn (a,b)
Duraloy Co., Pa (g)
East Birmingham Bronze Foundry Co., Ala (a,b)
Eastern Malleable Iron Co., Del (g)
Ehrsam, J.B. & Sons Mfg. Co., Kan (c)
Eichinger, Charles F., La (a,b)
Electric Auto-Lite Co., Ohio (c)
Electric Materials Co., Pa (b)
Electric Steel Foundry Co., Ore (f,g)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Electron Corp., Colo (c,f)
Elk Engineering Works, Inc., Pa (a,b,c)
Elkhart Foundry & Machine Co., Inc., Ind (c)
Elkhart Iron Works, Mich (c)
Elyria Foundry Div., Chromalloy Corp., Ohio (c)
Emmaus Foundry & Machine Co., Pa (a,b,c)
Empire Foundry Co., Inc., Calif (c,g)
Empire Steel Castings, Inc., Pa (g)
Enterprise Wheel & Car Corp., Va (a, b,c)
Erie Bronze Co., Pa (a,b)
Erie Casting Co., Pa (c)
Erie Malleable Iron Co., Pa (c)
Eureka Electric Products Co., Pa (a,b)
Fahralloy Co., Ill (g)
Fairbanks, Morse & Co., Wis (c)
Fairfield Aluminum Castings Co., Iowa (a)
Falk Corp., Wis (g)
Federal Malleable Co., Wis (c)
Fischer Casting Co., Inc., NJ (a)
Fitchburg Foundry, Inc., Mass (c)
Flood City Brass & Electric Co., Pa (a,b)
Florence Pipe Foundry & Machine Co., NJ (c)
Florin Foundry & Mfg. Co., Pa (c)
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa (f,g)
Fort Worth Steel & Machinery Co., Tex (c)
Frederick Iron & Steel, Inc., Md (c)
Fremont Casting Co., Mass (c)
Frontier Bronze Corp., NY (a,b,f)
Fulton Foundry & Machines Co., Inc., Ohio (c)
G & C Foundry Co., Ohio (c)
Gale Mfg. Co., Mich (c)
Gardner-Denver Co., Ill (c)
Gartland Foundry Co., Ind (c)
General Alloys Co., Mass (f)
General Electric Co., Foundry Dept., NY (a,b,c,f,g)
General Foundry & Mfg. Co., Mich (c)
General Malleable Corp., Wis (c)
General Metals Corp., Calif (c)
General Motors Corp., Central Foundry Div., Mich (c)
General Motors Corp., Fabricast Div., Ind (a)
Georgia Iron Works, Ga (c)
Gibson & Kirk Co., Md (a,b,f)
Gilbert Brass Foundry Co., Mo (a,b)
Gillett & Eaton, Inc., Minn (a,c)
Glover Machine Works, Ga (g)
Gluntz Brass & Aluminum Foundry Co., Ohio (a,b,j)
Goslin Birmingham Mfg. Co., Inc., Ala (c)
Gowanda Furnaces, Inc., NY (c)
Grafton Foundry Co., Wis (c)
Graham, James Co., Conn (b)
Gra-Iron Foundry Corp., Iowa (c)
Green Bay Foundry & Machine Works, Wis (a,b,c)
Greenlee Foundry Co., Ill (c)
Grimm Foundry Co., Inc., NJ (c)
Gunite Foundries Corp., Ill (c,g)
H & H Foundry Machine Co., Pa (c)
Hailstead Foundry, Inc., Pa (c)
Hamilton Foundry & Machine Co., Ohio (c)
Hampden Brass & Aluminum Co., Mass (a,b,j)
Hansell-Elcock, Ill (c)
Hardinge Mfg. Co., Pa (c)
Hartford Electrical Steel Corp., Conn (g)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hays Mfg. Co., Pa (b)
Headford Bros. & Hitchins Foundry Co., Iowa (c)
Helmick Foundry-Machine Co., WVa (c)
Hewitt, John Foundry Co., NJ (a,b,c)
Hica, Inc., La (f,g)
Hills-McCanna Co., Ill (d)
Hobbs, Clinton E. Co., Mass (a,b,c)
Hodgson Foundry Co., Ill (a,b,c,d)
Hoffman Bronze & Aluminum Casting Co., Ohio (a,b)
Homestead Valve Mfg. Co., Pa (a,b,c, f)
Howard Foundry Co., Ill (a,b,c,e,f,g)
Humphrey Castings, Inc., Calif (a)
Hunt-Spiller Mfg. Corp., Mass (c,g)
I-F Mfg. Co., Ohio (c)
Illinois Iron & Bolt Co., Ill (a,f)
Independence Stove & Mfg. Co., Mo (c)
Indiana Brass Co., Inc., Ind (b)
Industrial-Ferguson Foundry Corp., NJ (a,b,f,j)
International Nickel Co., Inc., NY (f)
Iowa Malleable Iron Co., Iowa (c)
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Irwin Foundry & Mine Car Co., Pa (c)
Jamestown Malleable Iron Corp., NY (c)
Johnson Bronze Co., Pa (b)
Johnstone Foundries, Inc., Pa (c)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kanawha Mfg. Co., W. Va (c)
Kansas City Hay Press Co., Mo (c)
Kay-Brunner Steel Products, Inc., Calif (g)
Keen Foundry Co., Inc., Ind (c)
Kelly Foundry Co., Pa (c)
King-Seeley Corp., Mich (c)
Kingsport Foundry & Mfg. Corp., Tenn (a,b,c,f)
Klinzing, A.F. Co., Inc., Wis (c,g)
Koehring Co., Wis (c)
Kramer Bros. Foundry Co., Ohio (c)
Kutztown Foundry & Machine Corp., Pa (c)
L F M Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan (g)
Laconia Malleable Iron Co., NH (c)
Lake Erie Foundry Co., NY (c)
Lakeside Bronze, Inc., NY (a,b)
Lakeside Malleable Casting Co., Wis (c)
Langsenkamp-Wheeler Brass Works, Inc., Ind (a,b)
La Porte Foundry Co., Ind (a,c)
Larson, W.O. Foundry Co., Ohio (c)
Lattimer Foundry and Machine Co., Pa (a)
Lawrence Copper & Bronze Co., Pa (b)
Lawton, C.A. Co., Wis (a,c)
Lebanon Steel Foundry, Pa (g)
Le Baron, E.L. Foundry, Mass (c)
Lee Bros. Foundry Co., Inc., Ala (b)
Lehigh Foundries Co., Div. of Lehigh, Inc., Pa (c)
Leitelt Bros., Inc., Ill (a,b)
Letukas Foundry, Ind (c)
Lewistown Foundry & Machine Co., Pa (a,c,d)
Liberty Foundry Co., Mo (c,g)
Light Metals, Inc., Ind (a,e)
Lincoln Foundry Corp., Calif (c)
Lincoln Iron Works, Vt (a,c,g)
Link-Belt Co., Ill (c)
Littite Foundries, Inc., Mich (c)
Littlestown Hardware & Foundry Co., Inc., Pa (a,b,c)
Lloyd & Scott Brass Foundry, Inc., Del (a,b)
Lodge Mfg. Co., Pa (c)
Lodi Iron Works, Inc., Calif (c)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Long Beach Iron Works, Calif (c)
Long Foundry Co., Wash (c)
Lorain Brass Co., Ohio (b)
Los Angeles Steel Casting Co., Calif (g)
Ludlow Valve Mfg. Co., Inc., NY (c)
Lumen Bearing Co., NY (b,d,j)
Lynchburg Foundry Co., Castings Div., Va (c)
Macaulay, H.C. Foundry Co., Calif (c)
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa (g)
Madison Foundry Co., Ohio (c)
Magline, Inc., Mich (a,e)
Mallory, P.R. & Co., Inc., Ind (b,f,h)
Mansfield Brass & Aluminum Corp., Ohio (a,b)
Marshall Car Wheel & Foundry Co., Inc., Tex (c)
Massillon Steel Casting Co., Ohio (g)
McLanahan & Stone Corp., Pa (c)
McNally Pittsburgh Mfg. Co., Kan (c)
Meadville Malleable Iron Co., Pa (c)
Meehanite Metal Corp., NY (c)
Merrimac Brass, Mass (a,b,d,e,f)
Merriman Bros., Inc., Mass (b)
Metal Goods Corp., Mo (f)
Metropolitan Iron Foundry, NY (a,c)
Midwest Foundry Co., Div. of L.A. Darling Co., Mich (c,g)
Midwestern Foundries, Inc., Ind (c)
Milwaukee Aluminum & Brass Foundry, Wis (a,b)
Milwaukee Malleable & Grey Iron Works, Wis (c)
Milwaukee Valve Co., Wis (a,b)
Minneapolis Electric Steel Casting Co., Minn (g)
Missouri Steel Castings Co., Mo (g)
Model Brass Co., Inc., Ill (a,b)
Modern Brass Foundry & Mfg. Co., Ohio (a,b)
Moline Malleable Iron Co., Ill (c)
Monroe Steel Castings Co., Mich (g)
Montague Machine Co., Mass (b,c,f)
Moore Dry Dock Co., Calif (g)
Morrisville Foundry Co., Inc., Vt (c)
Morse, Fred W. Co., RI (a,j)
Mount Vernon Furnace & Mfg. Co., Ill (c)
Mueller Brass Co., Mich (a,b)—Ad p 357
Muskegon Piston Ring Co., Mich (b, c)
National Aluminum Co., Inc., Wis (a,b)

5 Supplier Materi

National Aluminum & Brass Foundry, Inc., Mo (a,b)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Brass Works, Inc., Calif (a,b,d,f)
National Grey Iron Foundry, Ill (c)
National Malleable & Steel Castings Co., Ohio (c,g)
National Steel & Shipbuilding Corp., Calif (c)
National Supply Co., Pa (g)
Neenah Foundry Co., Wis (c)
Newman Bros., Inc., Ohio (a,b)
Noble & Wood Machine Co., NY (c)
North Wales Foundry Co., Inc., Pa (c)
Northern Malleable Iron Co., Minn (c)
Nutmeg Crucible Steel Co., Conn (g)
Oak Hill Foundry & Machine Works, Ohio (c)
Oakes Bronze & Aluminum Co., Ohio (a,b)
Oakland Foundry & Machine Co., Mich (c)
Ohio Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Ohio Precision Castings, Inc., Ohio (a,b,f)
Ohio Steel Foundry Co., Ohio (f,g)
Oil City Iron Works, Tex (c)
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla (g)
Olderman Mfg. Corp., Conn (b)
Olds Alloys Co., Calif (a,b,d,f)
Olympic Steel Works, Wash (g)
Omaha Steel Works, Neb (g)
Oregon Brass Works, Ore (a,b)
Overmyer Mould Co., Inc., Ind (c,f,g)
Owen Pattern Foundry & Mfg Co., Inc., Va (a,b)
Pacific Brass Foundry of San Francisco, Calif (a,b,d,f,j)
Pacific Foundry Co., Ltd., Calif (c,g)
Palmyra Foundry Co., Inc., NJ (c)
Parker, Charles Co., Conn (a,b)
Parker-Street Castings Co., Ohio (c)
Paulson, Thomas & Son, Inc., NY (a,b,f,j)
Payne, F.S. Co., Mass (c)
Pelton Steel Casting Co., Wis (g)
Penn Steel Castings Co., Pa (g)
Pennsylvania Malleable Iron Corp., Pa (c)
Peoria Malleable Casting Co., Ill (c)
Pequonnock Foundry, Inc., Conn (c)
Perfecto Cast, Calif (f,g)
Perkins, Henry Co., Mass (c)
Permold Co., Ohio (a)
Pettibone Mulliken Corp., Ill (g)
Pittsburgh Foundry & Machine Co., Pa (c)
Pittsburgh Steel Foundry Corp., Pa (g)
Pohlman Foundry Co., Inc., NY (c)
Portland Iron Works, Ore (c)
Posey Iron Works, Inc., Pa (c,g)
Potts, C. & G. Co., Ind (c)
Pratt, William E. Mfg. Co., Ill (c)
Prescott Co., Mich (a,c)
Pusey & Jones Corp., Del (c)
Quaker Alloy Casting Co., Pa (c,f,g)
Quality Electric Steel Castings, Inc., Tex (g)
Quest, J.F. Foundry Co., Minn (c)
Quincy Steel Casting Co., Mass (g)
Racine Steel Castings Co., Belle City Malleable Iron Div., Wis (c)
Refinery Castings Co., Tex (g)
Reliance Foundry Co., Ohio (c)
Rensselaer Valve Co., NY (c)
Richmond Foundry & Mfg. Co., Inc., Va (a,b,c,d,f,j)
Ridge Foundry, Calif (c)
Riverside Foundry & Galvanizing Co., Mich (a,b,c,f)
Rolle Mfg. Co., Pa (a,e)
Rosedale Foundry & Machine Co., Pa (c)
Ross-Meehan Foundries, Tenn (c,g)
Saginaw Bearing Co., Mich (a,b)
St. Louis Malleable Casting Co., Mo (c)
St. Louis Steel Casting, Inc., Mo (g)
St. Marys Foundry Co., Ohio (c)
Sall Bros. Co., Ill (a,b)
San Francisco Iron Foundry, Calif (a,c)
Sandy Hill Iron & Brass Works, NY (a,b,c)
Saran Lined Pipe Co., Mich (c,g)
Sargent & Greenleaf, Inc., NY (a,b)
Schaefer-Goodnow Foundries, Inc., Pa (c)
Schilling Bronze Co., NY (a,b,d,f,j)
Schmeller Aluminum Foundry Co., Ohio (a)
Schneider, Bowman Co., Inc., Pa (c)
Scottdale Ozone Co., Pa (a,c)
Scovill Mfg. Co., Mill Products Div., Conn (b)
Scudder, E. J. Foundry & Machine Co., NJ (f,g)
Scullin Steel Co., Mo (g)
Searjeant Metal Products, Inc., NJ (a,c)
Selma Foundry & Machine Co., Ala (c)
Sequoia Metalcraft Co., Inc., Calif (e)
Shakopee Foundry Co., Minn (c)
Sharpsville Steel Fabricators, Inc., Pa (c,g)
Shartle Div., Black-Clawson Co., Ohio (a,b,c)
Sheffield Foundry Co., Ill (c)
Shenango Furnace Co., Ohio (c)
Sherman & Reilly, Inc., Tenn (a,c,g)
Shriver, T. & Co., Inc., NJ (a,b,c,d)
Sibley Machine & Foundry Corp., Ind (c)
Sinclair Co., Mass (a,b)
Sioux City Foundry & Boiler Co., Iowa (a,c)
Sivyer Steel Casting Co., Wis (g)
Smith, A.P. Mfg. Co., NJ (c)
Smith & Winchester Mfg. Co., Conn (a,b,c,g)
Solon Foundry, Inc., Ohio (a,b,e)
Somerset Foundry & Machine Co., Pa (a,c,d)
Sonith Foundries, Food Machinery Corp., Ind (b,c)
Sorbo-Cast Corp., NJ (c)
Sorbo-Mat Process Engineers, Mo (c)—Ad p 355
Southern Metal Products Co., La (a)
Sparta Foundry Div., Muskegon Piston Ring Co., Mich (b,c)
Spencer's, I.S. Sons, Inc., Conn (a,b,c)
Spring City Foundry Co., Pa (c)
Springer's Foundry Co., Inc., Ind (a,c)
Springfield Foundry Co., Mass (c)
Spuck Iron & Foundry Co., Mo (c)
Stainless Foundry & Engineering, Inc., Wis (f,g)
Standard Casting Corp., Ill (a,b,d)
Standard Foundry Co., Mass (c)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Stanwood Corp., Ill (g)
Star Heel Plate Co., Inc., NJ (c,g)
State Foundry & Machine Co., Wis (c)
Stearns-Roger Mfg. Co., Colo (c)
Sterling Brass Foundry, Inc., Ind (a,b)
Sterling Foundry Co., Inc., Ill (a,b,c)
Sterrit-Thomas Foundry Co., Pa (c)
Stillman White Foundry Co., Inc., RI (a,b,d)
Strong Steel Foundry Co., NY (g)
Stuart Foundry Co., Mich (c)
Stulz-Sickles Co., NJ (g)
Superb Light Alloys, Inc., NY (a,e)
Superior Foundry, Inc., Ohio (c,g)
Swayne-Robinson & Co., Ind (a,c)
Swedish Crucible Steel Co., Mich (g)
Swett, A.L. Iron Works, NY (c)
Taylor & Co., Inc., NY (c)
Taylor & Boggis Foundry, Ohio (c)
Terre Haute Bronze & Brass Foundry, Ind (b)
Terre Haute Malleable & Mfg. Corp., Ind (c)
Texas Foundries, Inc., Tex (c,g)
Thys Co., Calif (g)
Tower Grove Foundry, Mo (c)
Trenton Brass Co., NJ (b)
True Alloys, Inc., Mich (a,b,d,f,j)
Turner & Seymour Mfg. Co., Conn (c)
Union Iron Works, Wash (c,g)
Unitcast Corp., Ohio (g)
U.S. Pipe and Foundry Co., Ala (c)
U.S. Steel Corp., Oil Well Supply Div., Tex (c,g)
Uniworld Research Corp. of America, Ohio (c)
Utica General Jobbing Foundry, Inc., NY (c)
Utica Radiator Corp., NY (c)
Valley Iron Works, Inc., Minn (c)
Valley Steel Casting Co., Mich (g)
Viking Pump Co., Iowa (c)
Vollrath Co., Wis (a,b,g)
Vulcan Foundry Co., Calif (c)
Vulcan Rail & Construction Co., NY (a,c,g)
Wagner Malleable Iron Co., Ill (c)
Wall Colmonoy Corp., Stainless Process Div., Mich (c,f)
Waltham Foundry Co., Mass (a,c)
Washington Iron Works, Wash (c)
Waterman Industries, Inc., Calif (a,b,c)
Waukesha Foundry Co., Wis (a,b,f,g)—Ad p 350
Wayne Agricultural Works, Inc., NC (b,c)
Wayne Foundry & Stamping Co., Mich (d,j)
Weber-Knapp Co., NY (a)
Webster Mfg. Inc., Ohio (c)
Wellman Bronze & Aluminum Co., Ohio (a,e)
Werner Foundry & Machine Co., Pa (c)
West Haven Foundry Co., Conn (a,b,d,f,j)
West Point Foundry & Machine Co., **Div. of Batson-Cook Co., Ga** (a,c,d)
West Steel Casting Co., Ohio (f,g)
Western Automatic Machine Screw Co., Ohio (c)
Western Foundry & Machine Works, Inc., Kan (c)
Western Iron & Foundry Co., Inc., Kan (c)
Westlectric Castings, Inc., Calif (g)
Westmoreland Malleable Iron Co., NY (c)
Whitehead Metal Products Co., Inc., NY (f)
Williams, A.C. Co., Ohio (e)
Williams, E.A. & Son, NJ (a,b)
Winters Foundry & Machine Co., Inc., Ohio (a,b,d,f,j)
Wisconsin Aluminum Foundry Co., Inc., Wis (a,b)
Wollaston Foundry Corp., Mass (c)
Woodruff & Edwards, Inc., Ill (c)
Worthington Corp., NJ (c)
Zenith Foundry Co., Wis (c)

Castings, Shell Mold

Abco Aluminum & Brass Works, Tex (a,b,d,f,j)
Aelco Foundries, Inc., Wis (a,b,f,g)
Albion Malleable Iron Co., Mich (c)
Alloy Precision Castings Co., Ohio (a,b,c,e,f,g)
Alloy Steel Casting Co., Pa (f,g)
Almont Mfg. Co., Mich (c)
American Aluminum Casting Co., NJ (a)
American Cast Iron Pipe Co., Ala (c)
American Manganese Steel Div., American Brake Shoe Co., Ill (g)
American Steel Foundries, Ill (g)
Ampco Metal, Inc., Wis (b)
Atlas Foundry & Mfg. Co., Calif (a,b,c,g)
Aurora Metal Co., Ill (b)
Austenal, Inc., NY (a,c,f,g)
Auto Specialties Mfg. Co., Mich (g)
Baxter Foundry & Machine Works, Inc., Ind (c)
Bendix Foundries, NJ (a,e)
Bethlehem Steel Co., Pa (g)
Blaw-Knox Co., Pa (f,g)
Buckeye Brass & Mfg. Co., Ohio (a,b)
Cadillac Malleable Iron Co., Mich (c)
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich (c)
Chicago Hardware Foundry Co., Ill (a,b,c)
Chicago Malleable Castings Co., Ill (c)
Cochrane Foundry, Inc., Pa (a,b,j)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Cooper Alloy Corp., NJ (g)—Ad p 353
Crucible Steel Co. of America, Pa (c,g)
Crucible Steel Casting Co., Pa (g)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g)
Dayton Malleable Iron Co., Ohio (c)
Dirilyte Co. of America, Inc., Ind. (b)
Duraloy Co., Pa (f)—Ad p 359
Electric Steel Foundry Co., Ore (f,g)
Electro-Alloys Div., American Brake Shoe Co., Ohio (g)
Electron Corp., Colo (c)
Emmaus Foundry & Machine Co., Pa (a,b,c)
Empire Steel Castings, Inc., Pa (g)
Erie Casting Co., Pa (c)
Fischer Casting Co., Inc., NJ (a)
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa (f,g)
Gale Mfg. Co., Mich (c)
General Electric Co., Foundry Dept., NY (f,g)
General Motors Corp., Central Foundry Div., Mich (c)
General Motors Corp., Fabricast Div., Ind (a)
Gilbert Brass Foundry Co., Mo (a,b)
Grimm Foundry Co., Inc., NJ (c)
Gunite Foundries Corp., Ill (c,g)
Hica, Inc., La (g)
Hobbs, Clinton E. Co., Mass (a,b,c)
Howard Foundry Co., Ill (a,b,c,e,f,g)
Investment Casting Co., NJ (a,b,c,f,g)
Ironton Malleable Div., Dayton Malleable Iron Co., Ohio (c)
Jamestown Malleable Iron Corp., NY (c)
Laconia Malleable Iron Corp., NH (c)
Lakeside Malleable Casting Co., Wis (c)
Lebanon Steel Foundry, Pa (g)
Lehigh, Inc., Pa (c)
Liberty Foundry Co., Mo (c,g)
Loeffler, J.M. Co., Machine & Brass Works, Pa (b)
Lumen Bearing Co., NY (b)
Lynchburg Foundry Co., Castings Div., Va (c)
Mallory, P.R. & Co., Inc., Ind (b)
Marshall Car Wheel & Foundry Co., Inc., Tex (c)
Massillon Steel Casting Co., Ohio (g)
McCarter Iron Works, Inc., Pa (c,g)
Meehanite Metal Corp., NY (c)
Mercast Mfg. Corp., Calif (a,b,c,e,f,g)
Metal Goods Corp., Tex (c,f)
Michigan Steel Casting Co., Div. of Consolidated Foundries & Mfg. Corp., Mich (g)
Midwest Foundry Co., Div. of L.A. Darling Co., Mich (c,g)
Misco Precision Casting Co., Mich (c,f,g)
Missouri Diecasting Co., Mo (a,b,c,g)
National Bearing Div., American Brake Shoe Co., Pa (b)
National Lead Construction Co., Inc., NJ (d)
National Malleable & Steel Castings Co., Ohio (c)
Northern Malleable Iron Co., Minn (c)
Ohio Steel Foundry Co., Ohio (f,g)
Oklahoma Steel Casting Div., American Steel & Pump Corp., Okla (g)
Olderman Mfg. Corp., Conn (j)
Olympic Steel Works, Wash (g)
Oregon Brass Works, Ore (a,b)
Pacific Brass Foundry of San Francisco, Calif (a,b,f,j)
Parker, Charles Co., Conn (a,b)
Pelton Steel Casting Co., Wis (f,g)
Perfecto Cast, Calif (f,g)
Pettibone Mulliken Corp., Ill (g)
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY (g)
Precision Castparts Corp., Ore (a,b,f,g)
Pusey & Jones Corp., Del (c)
Quaker Alloy Casting Co., Pa (c,f,g)
Racine Steel Castings Co., Belle City Malleable Iron Div., Wis (c,g)
Ridge Foundry, Calif (c)
Rolle Mfg. Corp., Pa (a,e)
Ross-Meehan Foundries, Tenn (c,g)
Sall Bros. Co., Ill (a,b)
Schilling Bronze Co., NY (a,b,d)
Sorbo-Mat Process Engineers, Mo (c)—Ad p 355
Spencer's, I.S. Sons, Inc., Conn (c)
Star Heel Plate Co., Inc., NJ (a,b,c,g)
State Foundry & Machine Co., Wis (c)
Superb Light Alloys, Inc., NY (a,e)
Taylor & Co., Inc., NY (c)
Texas Foundries, Inc., Tex (c,g)
Trenton Brass Co., NJ (b)
True Alloys, Inc., Mich (a,b,d,f,j)
Unitcast Corp., Ohio (g)
Uniworld Research Corp. of America, Ohio (c)
Utica General Jobbing Foundry, Inc., NY (c)
Utility Steel Foundry, Calif (c,g)
Vanadium-Alloys Steel Co., Pa (g)
Wall Colmonoy Corp., Stainless Process Div., Mich (c,f)
Washington Iron Works, Wash (c)
Waterman Industries, Inc., Calif (b,c)
Waukesha Foundry Co., Wis (a,b,f,g)—Ad p 350
Wayne Agricultural Works, Inc., NC (b,c)
West Steel Casting Co., Ohio (f,g)
Western Automatic Machine Screw Co., Ohio (c)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Winters Foundry & Machine Co., Inc., Ohio (a,b,d,f,j)
Woodruff & Edwards, Inc., Ill (c)
Zenith Foundry Co., Wis (c)

Cellophane

(see Cellulose, Regenerated)

Cellulose Acetate

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Albany Novelty Mfg. Co., Mass (t)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Products Mfg. Co., La (t)
Anchor Plastics Co, Inc., NY (bb,dd,ee)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Blank, Arthur & Co., Inc., Mass (t,cc)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Capac Industries, Inc., Mich (cc)
Carroll, J.B. Co., Ill (cc)
Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Celanese Corp. of America, Plastics Div., NJ (p,s,t,y,cc)—Ad pp 183-86
Celluplastic Corp., NJ (bb,ee)
Chemical Development Corp., Mass (p)
Chicago Molded Products Corp., Campco Div., Ill (t,cc)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (t,bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,ee)—Ad p 182
Craftint Mfg. Co., Ohio (cc)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
du Pont de Nemours, E.I. & Co., Inc., Del (p)
du Pont de Nemours, E.I. & Co., Inc., Film Div., Del (t)
du Pont de Nemours, E.I. & Co., Inc., Polychemicals Div., Del (cc)
du Pont de Nemours, E.I. & Co., Inc., Textile Fibers Div., Del (s)
Dura Plastics of New York, Inc., NY (cc)
Eastman Chemical Products, Inc., Tenn (p,y)
Eastman Kodak Co., Cellulose Products Sales Div., NY (t,cc)
Eljay Corp., Md (cc)
Falge Engineering Corp., Md (t)
Fry Plastics Co., Calif (t,cc)
General Gasket, Inc., Conn (t,cc)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Products, Inc., NJ (y)
Glass Laboratories, NY (bb,dd)
Gomar Mfg. Co., Inc., NJ (cc)
Hastings & Co., Inc., Pa (t)
Hercules Powder Co., Inc., Del (p)
Industrial Plastics Corp., Ind (bb,dd)
Insulation Mfrs. Corp., Ill (t,cc,dd)
Jet Specialties Co., Inc., Calif (bb,cc,dd,ee)
Knoedler Chemical Co., Pa (bb,cc)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc)
Midwest Plastic Products Co., Ill (t,cc)
Monsanto Chemical Co., Plastics Div., Mass (t)
Muehlstein, H. & Co., Inc., NY (y)
National Gasket & Washer Mfg. Co., Inc., NY (cc,dd)
New England Tape Co., Inc., Mass (bb,cc)
Nixon Nitration Works, NJ (bb,cc,ee)
Norrich Plastics Corp., NY (bb,cc,ee)
Omni Products Corp., NY (y,bb,cc)
Ormond Mfg. Co., Inc., NJ (cc,dd)
Pacific Coast Foil Co., Calif (t)
Panelyte Div., St. Regis Paper Co., NY (cc)
Perfex Plastics, Inc., (bb,dd,ee)
Philrus Products Co., NJ (cc,dd)
Plast-Ad Mfg. Co., Ind (cc)
Plastic Materials, Inc., NY (y)
Precision Paper Tube Co., Ill (ee)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Reed Plastics Corp., Mass (y)
Rosco Laboratories, NY (cc)
Rowland Products, Inc., Conn (x,bb,cc,dd,ee)
Russell Mfg. Co., Conn (s)
Schwab Plastic Corp., Mich (u,bb,cc,dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Simon Products Co., Ill (t,cc)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Stone Paper Tube Div., Stone Straw Corp., Washington, DC (ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd,ee)
Walsen Consolidated Mercantile Co., NY (bb,cc)
Western Felt Works, Ill (cc)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
World Plastex, NY (bb,cc,dd)
World Plastics, NY (bb,cc,dd,ee)

Cellulose Acetate Butyrate

aaRBee Plastic Co., Calif (y)
Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
Albany Novelty Mfg. Co., Mass (t,cc)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Assoc., Inc., Ohio (y)
Anesite Co., Ill (ee)
Auburn Plastics, Inc., NY (bb,cc,dd,ee)
Bamberger, Claude P., Inc., NJ (p,y)
Bischoff Chemical Corp., Conn (u)
Blank, Arthur & Co., Inc., Mass (t,cc)
Busada Mfg. Corp., NY (ee)—Ad p 356
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Carroll, J.B. Co., Ill (cc)
Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Celluplastic Corp., NJ (bb,ee)
Chicago Molded Products Corp., Campco Div., Ill (t,cc)
Coating Products, Inc., NJ (t,cc)
Colonial Kolonite Co., Ill (t,bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y)
Eastman Chemical Products, Inc., Tenn (p,y)
Eastman Kodak Co., Cellulose Products Sales Div., NY (t,cc)
Falge Engineering Corp., Md (t)
Fidelity Chemical Products Corp., NJ (u)
Fry Plastics Co., Calif (t,cc)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Products, Inc., NJ (y)
Glass Laboratories, NY (bb,dd)
Gomar Mfg. Co., Inc., NJ (cc)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
Jet Specialties Co., Inc., Calif (bb,cc,dd,ee)
K S H Plastics, Inc., Mo (bb,cc,dd)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc)
Midwest Plastic Products Co., Ill (t,cc)
Muehlstein, H & Co., Inc., NY (y)
New England Tape Co., Inc., Mass (bb,cc)
Nixon Nitration Works, NJ (bb,cc,ee)
Omni Products Corp., NY (y,bb,cc)
Panelyte Div., St. Regis Paper Co., NY (cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Precision Paper Tube Co., Ill (ee)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Rowland Products, Inc., Conn (x,bb,cc,dd,ee)
Schwab Plastic Corp., Mich (u,bb,cc,dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Shoe Form Co., Inc., NY (cc,dd,ee)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd,ee)
Western Felt Works, Ill (cc)
Western Plastics Corp., Neb (bb,dd,ee)
Westlake Plastics Co., Pa (bb,cc,dd,ee)

World Plastex, NY (bb,cc,dd)
World Plastics, NY (bb,cc,dd,ee)

Cellulose Nitrate

Adhesive Products Corp., NY (x)
Chemical Development Corp., Mass (p)
Crescent Plastics, Inc., Ind (ee)
du Pont de Nemours, E.I. & Co., Inc., Del (p)
du Pont de Nemours, E.I. & Co., Inc., Polychemicals Div., Del (cc)
Faige Engineering Corp., Md (t)
General Gasket, Inc., Conn (t)
Hercules Powder Co., Inc., Del (p)
Monsanto Chemical Co., Mass (t,bb, cc)
Nixon Nitration Works, NJ (bb,cc,ee)
Omni Products Corp., NY (bb,cc)
Panelyte Div., St. Regis Paper Co., NY (cc)
Rowland Products, Inc., Conn (x,cc)
Western Felt Works, Ill (cc)

Cellulose Propionate

aaRBee Plastic Co., Calif (y)
Adhesive Products Corp., NY(x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,ee)
Anderson Assoc., Inc., Ohio (y)
Celanese Corp. of America, Plastics Div., NJ (p,y)—Ad pp 183-186
Eastman Chemical Products, Inc., Tenn (y)
Panelyte Div., St. Regis Paper Co., NY (cc)
Perfex Plastic, Inc., Ill (bb,dd)
Southern Plastics Co., SC (bb,cc,dd,ee)
Superior Plastics, Inc., Ill (ee)
World Plastex, NY (bb,cc,dd)
World Plastics, NY (bb,cc,dd,ee)

Cellulose, Regenerated

(e.g., Cellophane)
Adhesive Products Corp., NY (x)
American Viscose Corp., Pa (t)
Blank, Arthur & Co., Inc., Mass (t)
Cadillac Plastic & Chemical Co., Mich (t)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
du Pont de Nemours, E.I. & Co., Inc., Del (s)
du Pont de Nemours, E.I. & Co., Inc., Film Div., Del (t,cc)
Foss Mfg. Co., Plastics Div., Id (t)
Mason Envelope Co., Inc., NY (t)
Olin Mathieson Chemical Corp., Film Div., NY (t)
Pacific Coast Foil Co., Calif (t)

Cemented Carbides

(see Cermets)

Centrifugal Castings

(see Castings)

Ceramic Coatings

(see Inorganic Coatings)

Ceramics

Adamas Carbide Corp., NJ (r)
American Lava Corp., Tenn (r,z,bb,ff)
Amersil Div., Engelhard Industries, NJ (r)
Brush Beryllium Co., Ohio (r,aa,bb,ee)
California Metal Enameling Co., Calif (r)
Carborundum Co., NY (r,z,bb,cc,ee)—Ad p 244
Centralab Div., Globe Union, Inc., Wis (r,u,z,bb,ee)—Ad p 246
Commercialores, Inc., SC (aa)
Coors Porcelain Co., Colo (r,z,bb,cc,ee)
Du-Co Ceramics Co., Pa (r,z,aa,bb,ee)
Edgar Plastic Kaolin Co., Fla (aa)
Electric Auto-Lite Co., Ohio (r)
Electrical Refractories Co., Ohio (r,bb, ee)
Electro Chemical Engineering & Mfg. Co., Pa (r)
Electro Refractories & Abrasives Corp., NY (r)
Emerson & Cuming, Inc., Mass (r,u)
Foote Mineral Co., Pa (aa)
Frenchtown Porcelain Co., NJ (r,bb, cc,ee)
General Ceramics Corp., NJ (r,u,z,aa, bb,cc,ee)
Gladding, McBean & Co., Calif (r,z, bb,cc,ee)
Glass Laboratories, NY (r)
Gulton Industries, Inc., NJ (r)
Industrial Tectonics, Inc., Mich (r)
Knight, Maurice A., Ohio (r)
Laboratory Equipment Corp., Mich (r, z,bb,cc,ee)
Louthan Mfg. Co., Div. of Ferro Corp., Ohio (r,z,bb,cc,ee)
Malvern Brick & Tile Co., Ark (r)
Mansol Ceramics Co., NJ (r)
McDanel Refractory Porcelain Co., Pa (r,bb,cc,ee)—Ad p 252
Metal & Thermit Corp., NJ (aa)
Metallizing Engineering Co., Inc., NY (aa)—Ad p 280
Metallizing Co. of Los Angeles, Inc., Calif (bb)
Mica Fabricating Co., NJ (r,u,z,bb,cc, ee)
Morganite, Inc., NY (r,aa,bb,ee)
Mycalex Corp. of America, NJ (r,bb)
Norton Co., Mass (r,aa,bb,ee)
Porcelain Products, Inc., Ohio (r,s,z, bb,ee)
Pyrosil, Inc., Ohio (r,aa,bb,cc,ee)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (r)
Refractory & Insulation Corp., NY (r, aa)
Russell Mfg. Co., Conn (r,s)
Sauereisen Cements Co., Pa (aa)
Saxonburg Ceramics, Pa (r,z,aa,bb,ff)
Stackpole Carbon Co., Pa (r)
Star Porcelain Co., NJ (r)
Steatite Div., American Lava Corp., Tenn (r,z,bb,ee)
Steward, D.M. Mfg. Co., Tenn (r)—Ad p 362
Stupakoff Div., Carborundum Co., Pa (r,s,aa,bb)
Sylvania Electric Products, Inc., Parts Div., Pa (r)
Thermal American Fused Quartz Co., NJ (r)
Thermal Refractories Corp., NJ (r,z, bb,cc,ee)
Thermo Materials, Inc., Calif (r,z,aa, bb,cc,ee)
U.S. Stoneware Co., Ohio (r)
Western Gold & Platinum Co., Calif (r)
Zirconium Corp. of America, Ohio (r, aa,bb,ee)

Cermets

Allegheny Ludlum Steel Corp., Pa (r)
American Brakeblok Div., American Brake Shoe Co., Mich (r)
American Sinteel Corp., NY (r)
Brush Beryllium Co., Ohio (r,aa)
Carborundum Co., NY (r)—Ad p 244
Climax Div., American Metal Climax, Inc., NY (r)
Electro Metallurgical Co., Div. of Union Carbide Corp., NY (aa)
Emerson & Cuming, Inc., Mass (r,u)
Firth Sterling, Inc., Pa (r)
General Electric Co., Metallurgical Products Dept., Mich (r)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (r, u,aa)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (r)
Hommel, O. Co., Pa (aa)
Industrial Tectonics, Inc., Mich (r)
Kanthal Corp., Conn (bb)
Kennametal, Inc., Pa (r,aa,bb,ee)—Ad p 255
Metal Hydrides, Inc., Mass (aa)
Metallizing Engineering Co., Inc., NY (aa)—Ad p 291
Metallizing Co. of Los Angeles, Inc., Calif (bb)
Sintercast Corp. of America, NY (r)
Steatite Div., American Lava Corp., Tenn (r,z,bb,ee)
Thermo Materials, Inc., Calif (r,z,aa, bb,cc,ee)
U.S. Stoneware Co., Ohio (r)
Zirconium Corp. of America, Ohio (r)

Chemical Conversion Coatings

(see Conversion Coatings)

Chloroprene Rubber

(Neoprene)
Adhesive Products Corp., NY (x)
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Atlas Mineral Products Co., Pa (c)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc, dd)
Belko Corp., Md (y)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (u,y)
Chicago Rubber Co., Inc., Ill (u,y)
Colonial Rubber Co., Ohio (y,cc,dd)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Coyne & Paddock, Inc., NY (cc)
Dayton Rubber Co., Ohio (y,bb,cc, dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (u,cc)
du Pont de Nemours, E.I. & Co., Inc., Elastomer Chemicals Div., Del (p,y)
Dutch Brand Div., Johns-Manville Corp., Ill (u,y,cc,dd)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Faultless Rubber Co., Ohio (u,y,bb, ee)
Flexfirm Products, Calif (s)
Flexible Tubing Corp., Conn (ee)
Foamade Industries, Mich (u)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Co., Conn (u)
Goshen Rubber Co., Inc., Ind (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Knight, Maurice A., Ohio (cc)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,x,y)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,cc,dd,ee)
Rogers Corp., Conn (u,y,cc,dd)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Sheller Mfg. Corp., Mich (u)
Snyder, M.L. & Son, Inc., Pa (cc,ee)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (u)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)—Ad p 216
U.S. Stoneware Co., NY (y)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y, bb,cc,dd,ee)

Chlorosulfonated Polyethylene Rubber

Adhesive Products Corp., NY (x)
Allis Rubber Div., Chicago-Allis Mfg. Corp., Ill (p)
Atlas Mineral Products Co., Pa (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (y)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (cc)
du Pont de Nemours, E.I. & Co., Inc., Elastomer Chemicals Div., Del (p,y)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Flexfirm Products, Calif (s)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Mid-States Rubber Products, Inc., Ind (y)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)

Letters in ( ) indicate materials and forms—turn page for key

Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p)
Rogers Corp., Conn (cc,dd)
Toyad Corp., Pa (t)
Vulcan Rubber Products Div., Reeves Bros., Inc, NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y, bb,cc,dd,ee)

Chlorotrifluoroethylene

(see Fluorocarbon)

Chromate Coatings

(see Conversion Coatings)

Chromium

Alloy Metal Powder, Inc., Iowa (aa)
Alloy Metal Products, Inc., Iowa (o,w)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Belmont Smelting & Refining Works, Inc., NY (w,aa)
Chicago Development Corp., Md (aa)
Dahlin, C.A. Co., Ill (cc,ee)
Electro Metallurgical Co., Div. of Union Carbide Corp., NY (aa)
Foote Mineral Co., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa)
Hull, R.O. & Co., Inc., Ohio (n)
K. & L. Plating Co., Pa (z)
Lakeland Industries, Minn (z)
Metal Hydrides, Inc., Mass (aa)
Metal & Thermit Corp., NJ (w)
Metals Disintegrating Co., Inc., NJ (aa)
Michigan Seamless Tube Co., Mich (ee)
Modern Plating Corp., Ill (n)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Sel-Rex Corp., NJ (n)
Shieldalloy Corp., NJ (aa)
Stevens, Frederic B., Inc., Mich (n)
Vanadium Corp. of America, NY (w)
Walmet Alloys Co., Mich (w)—Ad p 72
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)

Chromized Coatings

(see Diffusion Coatings)

Clad Metals

(key letters refer to base metals; see also Laminates, Metal-Metal)

Alabama Wire Co., Inc., Ala (a)
Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
Allegheny Ludlum Steel Corp., Pa (g)
Aluminum Co. of America, Pa (a)
American Silver Co., NY (b,c,f,g)
Arrow Metal Products Corp., NJ (a)
Bart Mfg. Corp., NJ (a,b,c,e,f,g,h)
Bartlett-Thompson Co., Inc., Mass (a, b,f)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (f,g)—Ad p 324
Borg-Warner Corp., Ill (g)
Copper & Brass Sales, Inc., Mich (a)
Darby Corp., Kan (a,f,g)
Driver-Harris Co., NJ (f)
Electric Materials Co., Pa (c)
Electric Steel Foundry Co., Ore (f,g)
Electronic Parts Mfg. Co., NJ (b)
Enamel Products Co., Ohio (a,g)
Fromson Orban Co., Inc., NY (b,f,g)
General Alloys Co., Mass (f,g)
General Finding & Supply Co., Industrial Div., Mass (b)
General Plate Div., Metals & Controls Corp., Mass (a,b,c,e,f,g,h,j)
Improved Seamless Wire Co., RI (b,f)
Johnson Bronze, Pa (a,b,d,g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kewaunee Engineering Corp., Wis (c)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b,c,f,g)
Manufacturers & Fabricators, Inc., Ohio (f,g)
Metal Goods Corp., Mo (f)
Metals & Controls Corp., Mass (a,b,c, f,g,h)
Moraine Products Div., General Motors Corp., Ohio (a,d)
National Galvanizing Co., Pa (g)
National Lead Co., NY (d)
National Lead Construction Co., Inc., NJ (d)
National-Standard Co., Mich (g)
Olin Mathieson Chemical Corp., Aluminum Div., NY (a)
Parish Pressed Steel Div., Dana Corp., Pa (a,g,j)
Pittsburgh Steel Co., Pa (b,f,g,j)
Presswork, Inc., Mich (b)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Reynolds Metals Co., Va (a)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (b,f)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Saginaw Bearing Co., Mich (b,g)
Sandy Hill Iron & Brass Works, NY (g)
Seattle Boiler Works, Inc., Wash (g)
Sharpsville Steel Fabricators, Inc., Pa (g)
Somers Brass Co., Conn (f)
Standard Metals Corp., Mass (a,b,c, f,g)
Sun Steel Co., Ill (a,g)
Superior Steel Div., Copperweld Steel Co., Pa (g)
Sylvania Electric Products, Inc., Parts Div., Pa (b,g)—Ad p 349
Werner, R.D. Co., Inc., NY (a,g)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (f,g,h)
Whitehead Metal Products Co., Inc., NY (f)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (f,g)
Worcester Wire Works Div., National-Standard Co., Mass (g)

Claddings

(see Organic Coatings; Clad Metals)

Coated Metals

(see Precoated Metals)

Cobalt and Its Alloys

Alloy Metal Products, Inc., Iowa (o, w)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Austenal, Inc., NY (w)
Belmont Smelting & Refining Works Inc., NY (n,w,aa)
Budek & Bock Spring Mfg. Co., Ill (ff)
Cannon-Muskegon Corp., Mich (w)
Carborundum Co., NY (v,bb,cc,ee,ff)
Crobalt, Inc., Mich (n,w,bb)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,z,cc,dd)
Driver, Wilbur B. Co., NJ (bb,dd,ff)
Driver-Harris Co., NJ (bb,dd)
Elgin National Watch Co., Abrasives Div., Ill (o,bb,dd,ff)
General Plate Div., Metals & Controls Corp., Mass (v,dd)
Hamilton Watch Co., Precision Metals Div., Pa (v,w,bb,cc,dd)
Hardy, Charles, Inc., NY (aa)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (o,q,v,z,bb,cc,dd, ee,ff)
Hoskins Mfg. Co., Mich (bb,dd)
K. & L. Plating Co., Pa (z)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o)
McGean Chemical Co., Ohio (aa)
Metal Hydrides, Inc., Mass (aa)
Michigan Seamless Tube Co., Mich (ee)
National-Standard Co., Mich (ff)
New Jersey Metals Co., NJ (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Oregon Metallurgical Corp., Ore (w)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Utica Metals Div., Kelsey-Hayes Co., NY (o,q,v,w,z,bb,cc,dd,ff)
Vanadium-Alloys Steel Co., Pa (aa)
Walmet Alloys Co., Mich (w)—Ad p 72
Wall Colmonoy Corp., Mich (w,bb)
Wallingford Steel Co., Conn (dd,ee)—Ad p 352
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)

Cold Extrusions

(see Impact Extrusions)

Cold Headed Parts

Abbott Ball Co., Conn (b,g)
Acme Machine Products Div., Serrick Corp., Ind (g)
Albany Products Co., Inc., Conn (b,f)
Allied Products Corp., Mich (g)
Allmetal Screw Products Co., Inc., NY (f,g,h)
Aluminum Co. of America, Pa (a)
American Car & Foundry Div., ACF Industries, Inc., NY (g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armco Steel Corp., Sheffield Div., Mo (g)
Art Wire & Stamping Co., NJ (a,b,c,d,f,g)
Bead Chain Mfg. Co., Conn (a,g)
Bridgeport Brass Co., Conn (b)
Camcar Screw & Mfg. Co., Ill (a,g,h)
Central Screw Co., Ill (a,b,c,f,g)
Champion Rivet Co., Ohio (c,g)
Chandler Products Corp., Ohio (g)
Chase Brass & Copper Co., Conn (b)
Chicago Rivet & Machine Co., Ill (a, c,g)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Cincinnati Pump & Mfg. Co., Inc., Ohio (g)
Clark Bros. Bolt Co., Conn (a,b,c,g)
Clendenin Bros., Inc., Md (a,b,c)
Cleveland Cap Screw Co., Ohio (a, b,f,g,h)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Deringer Metallurgical Corp., Ill (a, b,c,d,f,g)
Eaton Mfg. Co., Reliance Div., Ohio (a,g)
Elco Tool & Screw Corp., Ill (a,b,c,g)
Electric Materials Co., Pa (b)
General Findings & Supply Co., Industrial Div., Mass (b,f)
Gibson Electric Co., Pa (f)
Greene, G.G. Corp., Pa (g)
Grip Nut Co., Ind (a,b,g)
Harper, H.M. Co., Ill (a,b,f,g)
Hartford Machine Screw Co., Div. of Standard Screw Co., Conn (a,b,c,f,g)
Hassall, John, Inc., NY (a,b,c,d,f,g)—Ad p 401
Hercules Fastener Co., Ill (a,b,c,g,j)
Huck Mfg. Co., Mich (a,g)
Jaques Co., Mass (a,b,e,f,g,h)
Johnston & Funk Titanium Corp., Ohio (h)
Koehler Mfg. Co., Mass (c)
Lamson & Sessions Co., Ohio (a,b,c,f, g,h,)
McKinney Mfg. Co., Pa (a,b,c,d,f,g)
Metal Goods Corp., Mo (f)
Mid-West Screw Products Co., Mo (a, b,c,g)
Milford Rivet & Machine Co., Conn (a,b,c,g)
Murray Tube Works, Inc., NJ (a,b,j)
National Lock Co., Fastener Div., Ill (a,b,c,d,g)
National Screw & Mfg. Co., Ohio (a,b, f,g)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Pheoll Mfg. Co., Ill (a,b,c,g,h)
Pusey & Jones Corp., Del (c)
Reed & Prince Mfg. Co., Mass (a, b,c,g)
Republic Steel Corp., Ohio (g)
Russell, Burdsall & Ward Bolt & Nut Co., NY (a,b,j)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Shakeproof Div., Illinois Tool Works, Ill (a,b,g)
Standard Pressed Steel Co., Pa (a,b, f,g,h)
Torrington Co., Conn (b,g)
Townsend Co., Pa (a,b,g)
Tubular Rivet & Stud Co., Mass (a, b,c,g)
Union Screw & Mfg. Co., Pa (a,g)
United Screw & Bolt Corp., Ill (a,b,g)
United-Carr Fastener Corp., Mass (b,g)
Weatherhead Co., Ind (g)
Wesbar Stamping Corp., Wis (a,c,g)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Zeller Corp., Ohio (g)

Columbium and Its Alloys

American Silver Co., NY (v,dd)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (ee)
Damascus Tube Co., Pa (ee)
Electro Metallurgical Co., Div. of Union Carbide Corp., NY (w,aa)—Ad p 134
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 138-39
Hamilton Watch Co., Precision Metals Div., Pa (v,dd)
Hardy, Charles, Inc., NY (aa)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kawecki Chemical Co., NY (o,q,v,w,z, aa,bb,cc,dd,ff)

Kennametal, Inc., Pa (o,v,aa,dd)—Ad p 255
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,ee)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Metal Hydrides, Inc., Mass (aa)
Metals & Controls Corp., Mass (v,dd)
Molybdenum Corp. of America, Pa (o, w,z,aa,bb,cc,dd)
Oregon Metallurgical Corp., Ore (w)
Shieldalloy Corp., NJ (o,aa)
Techalloy Co., Inc., Pa (dd,ff)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
United Screw & Bolt Corp., Ill (bb,cc, dd,ff)
Vanadium Corp. of America, NY (w)
Wah Chang Corp., NY (n,w,v,aa,bb, dd,ff)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)

Composition Board

(see Wood)

Compression Moldings

(see Moldings)

Conversion Coatings, Anodic

(anodizers)

Abalon Precision Mfg. Corp., NY
Abco Aluminum & Brass Works, Tex
Acme Plating Co., Ohio
Aerolite Extrusion Co., Ohio
Aluminum Billets, Inc., Ohio
Aluminum Finishing Corp., Ind
American Emblem Co., Inc., NY
Auld, D.L. Co., Ohio
B L C Porous Materials Co., Calif
B & T Metals Co., Ohio
Biddle Screw Products Co., Ind
Bonnell, William L. Co., Inc., Ga
Briggs-Shaffner Co., NC
Brinkerhoff Brass & Bronze Works, Inc., NY
Brooks & Perkins, Inc., Mich
Chicago Thrift-Etching Corp., Ill
Colonial Alloys Co., Pa
Commercial Screw Products Co., Ohio
Corson Industries, Pa
Croname, Inc., Ill
Designers Metal Corp., Ill
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Edna Lite Optical Co., Inc., NY
Electric Auto-Lite Co., Ohio
Engineering Products & Specialties, Inc., RI
Fox Co., Ohio
General Extrusions, Inc., Ohio
Hull, R.O. & Co., Inc., Ohio
Industrial Chromium Corp., Mass
Jarl Extrusions, Inc., NY —Ad p 348
Kees, F.D., Mfg. Co., Neb
Kinkead Industries, Inc., Ill
Leed, H.A. Corp., Conn
Magnesium Co. of America, Ind
Magnesium Elektron, Inc., NY
Merz Machine & Tool Works, Ind
Metal Finishers, Inc., Md
Mirro Aluminum Co., Wis
Modern Plating Corp., Ill
National Aluminum Co., Ohio
National Galvanizing Co., Pa
National Gasket & Washer Mfg. Co., Inc., NY
Reed & Prince Mfg. Co., Mass
Reynolds Metal Co., Ky
Rustproofing & Metal Finishing Corp., Mass
Saramar Aluminum Co., Ohio
Schwartz Chemical Co., Inc., NY
Southern Aluminum Finishing Co., Inc., Ga
Spencer Nahm Co., Calif
Stevens, Frederic B, Inc., Mich
Trim Alloys, Inc., Mass
Udylite Corp., Mich
Vanamatic Co., Ohio
W L S Stamping Co., Ohio
Woodstock Div., Electric Auto-Lite Co., Ill
Youngstown Mfg. Inc., Ohio

Conversion Coatings, Chromate

(formulations)

Abalon Precision Mfg. Corp., NY
Acme Plating Co., Ohio
Allied Research Products, Inc., Md —Ad p 281
Amchem Products, Inc., Pa —Ad p 279
Chemical Corp., Mass —Ad p 291
Chemical Coatings & Engineering Co., Inc., Pa
Colonial Alloys Co., Pa
Conversion Chemical Corp., Conn
Diamond Alkali Co., Ohio
Dollin Corp., NJ
Enthone, Inc., Conn
Heatbath Corp., Mass
Hull, R.O. & Co., Inc., Ohio
MacDermid, Inc., Conn
Metal & Thermit Corp., NJ
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Oakite Products, Inc., NY
Octagon Process, Inc., NY
Parker Paint Mfg. Corp., Ind
Parker Rust Proof Co., Mich
Pierce & Stevens Chemical Corp., NY
Promat Div., Poor & Co., Ill
Thompson & Co., Pa
Turco Products, Inc., Calif
Vanamatic Co., Ohio
Zeller Corp., Ohio

Conversion Coatings, Chromate

(coaters)

Abalon Precision Mfg. Corp., NY
Acme Plating Co., Ohio
Amchem Products, Inc., Pa
American Agile Corp., Ohio
American Emblem Co., Inc., NY
Clad-Rex Corp., Ill
Colonial Alloys Co., Pa
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Du-Wel Metal Products, Inc., Mich
Eaton Mfg. Co., Reliance Div., Ohio
Electrofilm, Inc., Calif
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Hardy Mfg. Corp., Ind
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Modern Plating Corp., Ill
Norgren-Stemac, Inc., Colo
Promat Div., Poor & Co., Ill
Rustproofing & Metal Finishing Corp., Mass
Sommer Metalcraft Corp., Ind
Spencer Nahm Co., Calif
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Witt Cornice Co., Galvanizing Div., Ohio
Worth Co., Wis
Zeller Corp., Ohio

Conversion Coatings, Oxide

(formulations)

Birchwood Chemical Co., Minn
Dollin Corp., NJ
Enthone, Inc., Conn
Heatbath Corp., Mass
Houghton, E.F. & Co., Pa
Hull, R.O. & Co., Inc., Ohio
MacDermid, Inc., Conn
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Parker Paint Mfg. Corp., Ind
Promat Div., Poor & Co., Ill
Solvay Process Div., Allied Chemical Corp., NY —Ad p 289
Thompson & Co., Pa
Tube Reducing Corp., NJ
Vanamatic Co., Ohio
Zeller Corp., Ohio

Conversion Coatings, Oxide

(coaters)

Biddle Screw Products Co., Ind
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Electric Auto-Lite Co., Ohio
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Metallizing Co. of Los Angeles, Inc., Calif
Modern Plating Corp., Ill
Rustproofing & Metal Finishing Corp., Mass
Spencer Nahm Co., Calif
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio
Worth Co., Wis

Conversion Coatings, Phosphate

(formulations)

Ainsworth Precision Castings Co., Div. of Harsco Corp., Mich
Amchem Products, Inc., Pa —Ad p 279
Ashtabula Mfg. Co., Ohio
Detrex Chemical Industries, Inc., Mich
Dollin Corp., NJ
Farrelloy Co., Pa
Fidelity Chemical Products Corp., NJ
Houghton, E.F. & Co., Pa
Hull, R.O. & Co., Inc., Ohio
Kelite Corp., NJ
MacDermid, Inc., Conn
Magnuson Products Corp., NY
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Neilson Chemical Co., Mich
Oakite Products, Inc., NY
Octagon Process Inc., NY
Panther Chemical Corp., Tex
Parker Rust Proof Co., Mich
Pennsalt Chemicals Corp., Pa
Promat Div., Poor & Co., Ill
Rustproofing & Metal Finishing Corp., Mass
Sharon Steel Corp., Pa
Thompson & Co., Pa
Turco Products, Inc., Calif
Vanamatic Co., Ohio
Whitfield Chemical Co., Mich
Zeller Corp., Ohio

Conversion Coatings, Phosphate

(coaters)

Almco Steel Products Corp., Ind
Amchem Products, Inc., Pa
Ashtabula Mfg. Co., Ohio
Biddle Screw Products Co., Ind
Brandt, Charles T., Inc., Md
Clad-Rex Corp., Ill
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Electric Auto-Lite Co., Ohio
Electrofilm, Inc., Calif
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Grand Rapids Brass Co., Mich
Hardy Mfg. Corp., Ind
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Modern Plating Corp., Ill
National Metal Products Co., Pa
Rustproofing & Metal Finishing Corp., Mass
Spencer Nahm Co., Calif
United Shoe Machinery Corp., Mass
U.S. Steel Corp., Oil Well Supply Div., Tex
United-Carr Fastener Corp., Mass
W L S Stamping Co., Ohio

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar polymers or gums
p—Base resins,
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Witt Cornice Co., Galvanizing Div., Ohio
Worth Co., Wis

Copper and Its Alloys

A & A Die Casting Co., Calif (cc)
Acme Tube, Inc., NJ (ee)
Ajax Metal Div., H. Kramer Co., Pa (w)
Alcasco Foundry, Ill (w)
Alloy Metal Products, Inc., Iowa (o,w)
Alofs Mfg. Co., Mich (dd)
Alpha Wire Corp., NY (ff)
American Brass Co., Sub. of Anaconda Co., NY (n,o,v,z,bb,cc,dd,ee,ff)
American Crucible Products Co., Ohio (o)—Ad p 136
American Manganese Bronze Co., Pa (o,bb)
American Metal Climax, Inc., NY (n,o,q,w,aa)—Ad p 132
American Nickel Alloy Mfg. Corp., NY (o)
American Sheet Metal Works, Inc., Conn (cc)
American Silver Co., NY (v,dd)
Ampco Metal, Inc., Wis (o,q,w,z,bb,cc,dd,ee,ff)
Anaconda Aluminum Co., Sub. of Anaconda Co., NY (q,w)
Atlantic Steel Co., Ga (cc,dd)
Atlas Brass Foundry, Calif (o)
Auld, D.L. Co., Ohio (n,cc,dd,ff)
Avril, G.A. Co., Ohio (w)
Babson Dow Mfg. Co., Mass (o)
Bart Mfg. Corp., NJ (aa)
Barth Smelting Corp., NJ (w)
Bay State Refining Co., Inc., Mass (w)
Belmont Smelting & Refining Works, Inc., NY (n,q,w,aa)—Ad p 130
Beryllium Corp., Pa (o,q,w,z,bb,cc,dd,ee,ff)
Biddle Screw Products Co., Ind (bb,ee)
Bohn Aluminum & Brass Corp., Mich (bb,ff)
Both, A.O. Corp., Mass (aa)
Bridgeport Brass Co., Conn (n,o,bb,cc,dd,ee,ff)
Bridgeport Rolling Mills Co., Conn (dd)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc,dd,ee,ff)
Bristol Brass Corp., Conn (o,z,bb,cc,dd,ff)
Brush Beryllium Co., Ohio (o,q,w,z,dd)—Ad p 130
Budek & Bock Spring Mfg. Co., Ill (ff)
Bullock, W.J., Inc., Ala (w)
Cerro de Pasco Sales Corp., NY (w,ee,ff)
Chase Brass & Copper Co., Conn (n,o,z,bb,cc,dd)
Chicago Extruded Metals Co., Ill (bb)
Clark Perforating Co., Mich (cc,dd)
Continuous Cast Products Dept., American Smelting & Refining Co., NY (o)
Copper & Brass Sales, Inc., Mich (n,o,q,v,z,bb,cc,dd,ee,ff)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,z,cc,dd)
Dahlin, C.A. Co., Ill (z,cc,ee)
Designers Metal Corp., Ill (cc)
Detroit Float & Stamping Co., Mich (o,bb,dd,ee)
Dixon Sintaloy, Inc., Conn (o)
Dormont Mfg. Co., Pa (ee)
Driver, Wilbur B. Co., NJ (bb,dd,ff)—Ad p 131
Driver-Harris Co., NJ (bb,dd)
Eastern Rolling Mills, Inc., NY (cc,dd)
Electric Materials Co., Pa (n,o,bb)
Empire Metal Co., NY (n,o)
Erskine Precision Wire Corp., Pa (ff)
Federated Metals Div., American Smelting and Refining Co., NY (n,o,q,w,bb,ee)
Fromson Orban Co., Inc., NY (z,cc,dd,ee)
General Cable Corp., NY (ff)
General Plate Div., Metals & Controls Corp., Mass (v)
Glidden Co., Chemicals-Pigments-Metals Div., Md (aa)—Ad p 347
Gold Leaf & Metallic Powders, Inc., NY (aa)
Grand Rapids Brass Co., Mich (z)
Greenback Industries, Inc., Mich (aa)
H & H Tube & Mfg. Co., Mich (dd,ee)
Hamilton Watch Co., Precision Metals Div., Pa (v,bb,cc,dd,ff)
Hardy, Charles, Inc., NY (aa)
Harris, Benjamin & Co., Ill (w)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hettleman K. & Sons., Inc., Md (w)
Hodgson Foundry Co., Ill (n,o,z)
Hoffman Bronze & Aluminum Casting Co., Ohio (n)
Hommel, O. Co., Pa (aa)
Hoskins Mfg. Co., Mich (bb,dd)
Hull, R.O. & Co., Inc., Ohio (n)
Hussey, C.G. & Co., Pa (n,o,v,z,bb,cc,dd,ee)
Inshield Die & Stamping Co., Ohio (dd)
Inspiration Consolidated Copper Co., NY (n,o,q)
Instrument Specialties Co., Inc., NJ (dd)
International Minerals & Metals Corp., NY (w)
International Powder Metallurgy Co., Inc., Pa (z,aa,ee)
Jelliff, C.O. Mfg. Corp., Conn (ff)
Jordan-Rogers Co., Calif (ff)
K. & L. Plating Co., Pa (z)
Kenmore Machine Products, Inc., NY (ee)
Kinkead Industries, Inc., Ill (cc,dd)
Lakeland Industries, Minn (z)
Laminated Shim Co., Conn (cc)—Ad p 340-41
Langsenkamp, F.H. Co., Ind (o,z,bb,cc,dd,ee,ff)
Lavin, R. & Sons, Inc., Ill (n,w)
Leach & Garner Co., Industrial Div., Mass (v,bb,cc,dd,ee,ff)
Lewin-Mathes Div., Cerro De Pasco Corp., Mo (q,w,bb,ee)
Loewenthal Metals Corp., Ill (w)
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Mackenzie Walton Corp., RI (ee)
Magna Mfg. Co., Inc., NJ (aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee,ff)
Mallory, P.R. & Co., Inc., Ind (o,bb,dd,ff)
Malone Bronze Powder Works, Inc., NY (aa)
Malone Metal Powders, Inc., NJ (aa)
McGean Chemical Co., Ohio (a,dd)
McGregor-Michigan Corp., Mich (ee)
Metal & Thermit Corp., NJ (n)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Miller Co., Conn (cc)
Modern Plating Corp., Ill (n,o,dd,ff)
Mueller Brass Co., Mich (bb)—Ad p 357
Murray, A.B. Co., Inc., NJ (ee)
National Electric Products Corp., Pa (ff)
National Lead Co., NY (ee)
Nesor Alloy Products Co., NJ (dd,ff)
New England Brass Co., Mass (cc,dd)
New England Electrical Works, Inc., NH (ff)
New England Smelting Works, Inc., Mass (w)
New Haven Copper Co., Conn (n,z,cc,dd)
New Jersey Metals Co., NJ (n,w)
New Jersey Zinc Co., NY (aa)—Ad p 325
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Norwalk Powdered Metals, Inc., Conn (aa)
Olds Alloys Co., Calif (ee)
Olin Mathieson Chemical Corp., NY (cc)
Ormond Mfg. Co., Inc., NJ (dd,ff)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Penn Brass & Copper Co., Pa (ee)
Phelps Dodge Copper Products Corp., Pa (dd)
Phelps Dodge Refining Corp., NY (n,o)
Precision Tube Co., Inc., Pa (ee)
Rathbone Corp., Mass (o,bb)
Republic Metals Co., Inc., NY (n,w)
Revere Copper & Brass, Inc., NY (n,o,v,z,bb,cc,dd,ee)
Revere Copper & Brass, Inc., Foil Div., NY (v)
Reynolds Aluminum Supply Co., Ga (o,z,bb,cc)
Rigidized Metals Corp., NY (cc,dd)
River Smelting & Refining Co., Ohio (w)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (bb,dd,ff)
Roebling's, John A. Sons Corp., NJ (bb,dd,ff)
Rome Mfg. Div., Revere Copper & Brass, Inc., NY (n)
Saginaw Bearing Co., Mich (o,q)
Sall, George Metals Co., Inc., Pa (w)
Sandusky Foundry & Machine Co., Ohio (ee)
Schumann, I. & Co., Ohio (w)
Scovill Mfg. Co., Mill Products Div., Conn (bb,cc,dd,ee,ff)—Ad pp 125-6
Sel-Rex Corp., NJ (n,aa)
Seymour Mfg. Co., Conn (n,bb,cc,dd,ff)—Ad p 133
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (ee)
Sipi Metals Corp., Ill (w)
Somers Brass Co., Inc., Conn (v,dd)—Ad pp 136, 139
Sonken-Galamba Corp., Mo (w)
Stamford Rolling Mills Co., Inc., Conn (cc)
Standard Metals Corp., Mass (ee,ff)
Star Heel Plate Co., Inc., NJ (ff)
Stevens, Frederic B., Inc., Mich (n)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)—Ad p 349
Terre Haute Bronze & Brass Foundry, Ind (bb,cc,dd,ee)
Thinsheet Metals Co., Conn (cc)
Titan Metal Mfg. Co., Pa (o,bb)
Triangle Conduit & Cable Co., Inc., NJ (bb,ee,ff)
Udylite Corp., Mich (n,o,bb)
Ullmann, Inc., Wis (o,ee)
U.S. Bronze Powder Works, Inc., NJ (aa)
U.S. Metal Products Co., Pa (w)
U.S. Steel Corp., Pa (ff)
United Wire & Supply Corp., RI (ee,ff)
Universal Castings Corp., Ill (w)
Utica Metals Div., Kelsey-Hayes Co., NY (o,q,v,w,z,bb,cc,dd,ff)
Utility Mfg. Co., Mass (o,bb)
Viking Copper Tube Co., Ohio (ee)
Volco Brass & Copper Co., NJ (cc)
Wall Tube & Metal Products Co., Tenn (ee)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., Ill (ee)
Waterbury Rolling Mills, Inc., Conn (cc,dd)—Ad p 129
Wells, A.H. & Co., Inc., Conn (ee)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)
Whitaker Metals Corp., Mo (aa)
Whitehead Metal Products Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Wright, Albert Screw Machine Products, Calif (bb)

Cordierite

(see Ceramics)

Cork

Armstrong Cork Co., Pa (r)
Conolite Div., Continental Can Co., Del (bb,cc,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (r,aa,cc)
Dutch Brand Div., Johns-Manville Corp., Ill (r,cc)
Enamel Products Co., Ohio (r)
General Gasket, Inc., Conn (r)
Hollingsworth & Vose Co., Mass (r)
National Gasket & Washer Mfg. Co., Inc., NY (r,cc)
Newth Rubber Co., RI (cc)
Peerless Products Industries, Ill (r)
Sheller Mfg. Corp., Mich (r,bb,cc,ee)
Spring Packing Corp., Ill (r)
Staver Co., Inc., NY (r,cc)
United Cork Cos., NJ (r)

Corrugated Metals

Aetna Steel Co., Fla (g)
Albert Pipe Supply Co., Inc., NY (g)
Aluminum Co. of America, Pa (a)
American Sheet Metal Works, Inc., Conn (a,g)
Armco Steel Corp., Ohio (g)
Atlantic Steel Co., Ga (g)
Bethlehem Steel Co., Pa (c,g)
Biersach & Niedermeyer Co., Wis (a,b,g)
Cartwright, R. Tube Products Co., Mich (a)
Clendenin Bros., Inc., Md (a)
Colonial Alloys Co., Pa (a)
Conner Mfg. Co., Ky (c)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Electric Steel Foundry Co., Ore (g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Gulfoy Cornice Works, Calif (a,c)
Hussey, C.G. & Co., Div. of Copper Range Co., Pa (b)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (j)
Inland Steel Co., Ill (g)
Johnson Metal Hose, Inc., Conn (b,f,g)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kelley Mfg. Co., Tex (a,g)
Levinson Steel Co., Pa (a,g)
New York Iron Roofing & Corrugating Co., Inc., NJ (a,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Reynolds Metals Co., Va (a)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Sun Steel Co., Ill (a,g,h)
U.S. Steel Corp., Pa (g)

Cupro-Nickel

(see Copper)

Diallyl Phthalate

(DAP)
Cordo Chemical Corp., Conn (x,y)
Durez Plastics Div., Hooker Chemical Corp., NY (y)—Ad pp 192-93

FMC Organic Chemicals Div., Food Machinery & Chemical Corp., NY (p)
Fiber Glass Industries, Inc., NY (x, y,cc)
Formica Corp., Sub. of American Cyanamid Corp., Ohio (bb,cc,dd)
Hays Mfg. Co., Pa (y)
Interchemical Corp., NY (p,x,y)
Maloney, F.H. Co., Tex (y)
Mesa Plastics Co., Calif (p,y,bb,cc)
Mico Corp., Calif (x)
Reichhold Chemicals, Inc. , NY (p,x)
Spaulding Fibre Co., Inc., NY (bb,cc,dd,ee)
Synthane Corp., Pa (bb,cc,dd,ee)
U.S. Polymeric Chemicals, Inc., Conn (s)

Die Castings

(see Castings)

Diffusion Coatings

(calorized, chromized, sherardized)

Calorizing Co., Pa
Chromalloy Corp., NY —Ad p 282
Colonial Alloys Co., Pa
General Extrusions, Inc., Ohio
Kelley Mfg. Co., Tex
Metal Finishers, Inc., Md
Modern Plating Corp., Ill
Vanamatic Co., Ohio

Dip Coatings

(see Immersion Coatings; Galvanizers)

Dispersion Coatings

(see Organic Coatings)

Drawn, Pressed Parts

(not incl. stampings)

Abalon Precision Mfg. Corp., NY (a, b,c,g)
Ackermann Mfg. Co., W. Va (g)
Acme Metal Spinning, Inc., Minn (a, b,c,d,e,f,g,h,j)
Acme Stamping & Mfg. Co., Pa (a,b, g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Alco Products, Inc., NY (g)
Alloy Products Corp., Wis (a,f,g,h)—Ad p 348
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a,g)
American Brass Co., Conn (a,b,c,f,g,j)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Forge & Mfg. Co., Pa (g)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (f,g,h)
American Silver Co., Inc., NY (a,b,e, f,g)
Anchor Metal Spinning Co., Ohio (a, b,c,d,f,g)
Anthes Force Oiler Co., Iowa (a,g)
Armco Steel Corp., Sheffield Div., Mo (g)
Arrow Metal Products Corp., NJ (a)
Art Wire & Stamping Co., NJ (a,b,c, e,f,g,h,j)
Arvin Industries, Inc., Ind (a,g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Atlas Metal Parts Co., Wis (a,b,c,g)
Auld, D.L. Co., Ohio (c)
Belmont Smelting & Refining Works, NY (a,b,g)
Bethlehem Steel Co., Pa (c,g)
Boots Aircraft Nut Corp., Conn (g)
Bossert Div., Rockwell Spring and Axle Co., NY (a,b,g)
Brandt, Charles T., Inc., Md (a,b,e,g)
Brooks & Perkins, Inc., Mich (a,e,g,h)—Ad p 362
Carpenter Steel Co., Pa (g)
Chase Brass & Copper Co., Conn (b)
Cleveland Hardware & Forging Co., Ohio (g)
Cly-Del Mfg. Co., Conn (a,b,f,g,j)
Colonial Alloys Co., Pa (a)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Commercial Shearing & Stamping Co., Ohio (a,f,g)
Consolidated Fruit Jar Co., NJ (a,b, c,d,g,j)
Cooley, W.J. & Co., Tenn (a,b,c,g)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa (g, h)
Cuyahoga Stamping Co., Ohio (a,b,g)
Cyril Bath Co., Ohio (a,e,f,g,h)
Dahlin, C.A. Co., Ill (a,b,f,g,j)
Dayton Rogers Mfg. Co., Minn (a,b, c,g,j)
Detroit Stamping Co., Mich (a,b,g)
Dirilyte Co. of America, Inc., Ind (a,b)
Division Lead Co., Ill (d)
Dow Chemical Co., Magnesium Div., Mich (e)
Eastern Tool & Mfg. Co., NJ (a,b,c,d, g,h)
Eaton Mfg. Co., Reliance Div., Ohio (g)
Edgcomb Steel & Aluminum Corp., NJ (g)
Electric Auto-Lite Co., Ohio (c)
Electric Materials Co., Pa (b)
Electric Steel Foundry Co., Ore (g)
Etched Products Corp., NY (a,b,g)
Falstrom Co., NJ (a,b,e,f,h)
Farwell Metal Fabricating, Minn (a,b, e,g)
Fletcher Enamel Co., W. Va (a,b,c,d, e,f,g)
Forg, Peter Mfg. Co., Mass (a,b,c,h)
Frasse, Peter A. & Co., Inc., NY (a,g)
Garco Mfg. Co., Inc., Ill (a,b,c,e,f,g, h,j)
General Alloys Co., Mass (a,b,c,f,g)
General Findings & Supply Co., Industrial Div., Mass (b,f,g)
General Plate Div., Metals & Controls Corp., Mass (a,b,c,e,f,g,h,j)
Geuder, Paeschke & Frey Co., Wis (a, c,f,g)
Grammes, L.F. & Sons, Inc., Pa (a, b,c,g)
H & H Tube & Mfg. Co., Mich (b)
Hydroforming Co. of America, Ill (a, b,g)
Ideal Can Co., Mass (a,b,g)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (j)
Ingersoll Products Div., Borg-Warner Corp., Ill (g)
Inland Steel Co., Ill (g)
International Silver Co., Eyelet Specialty Div., Conn (a,b,g)
Irwin Foundry & Mine Car Co., Pa (g)
Jones & Laughlin Steel Corp., Pa (g)
Kees, F.D. Mfg. Co., Neb (a,g)
Kelley Mfg. Co., Tex (a,g)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Koehler Mfg. Co., Mass (a,b,c,g)
Latrobe Steel Co., Pa (g)
Leake Engineering Co., Mich (a,b,c, d,e,f,g,h,j)
Leake Stamping Div., Monarch Products Co., Mich (a,b,f,g,h)
Lenape Hydraulic Pressing & Forging Co., Pa (a,b,g)—Ad p 354
Linde Co., Div. of Union Carbide Corp., NY (g)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Lundquist Tool & Mfg. Co., Inc., Mass (a,g)
Magline, Inc., Mich (a,e)
Magnesium Co. of America, Ind (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Mahon, R.C. Co., Mich (a,g)
Manganese Steel Forge Co., Pa (g)
Manufacturers Service, Inc., Ohio (a, b,g)
Matthiessen & Hegeler Zinc Co., Ill (j)
Midwest Stamping & Mfg. Co., Ohio (a,b,f,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
National Metal Products Co., Pa (a, b,d,g,j)
National Moldite Co., NJ (c)
Nichols, L.O. & Son Mfg. Co., Mo (a,b,c,g)
Nichols Wire & Aluminum Co., Iowa (a)
Olderman Mfg. Corp., Conn (b)
Parish Pressed Steel Div., Dana Corp., Pa (a,g)
Parker Metal Goods Co., Mass (a,b,g)
Peterson Products Corp., Ill (a,b,f,g)
Phoenix Products Co., Wis (a,b,c,f,g)
Pioneer Stamped Products Co., NY (a, b,e,f,g)
Pittsburgh Steel Co., Pa (b,c,f,g,j)
Powell Pressed Steel Co., Ohio (a,g)
Precision Extrusions, Inc., Ill (a)
Pressed Steel Co., Pa (a,b,f,g)
Pressed Steel Tank Co., Wis (a,b,c,e, f,g,h)
Queen Products Co., Inc., Ky (a,g)
Regal Ware, Inc., Wis (a,b,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a, b,c,f,g,j)
Reynolds Metals Co., Va (a)
Rockwell-Standard Corp., Stamping Div., NY (a,b,c,d,f,g,h,j)
Rolock, Inc., Conn (f)
Scaife Co., Pa (a,b,c,e,f,g,h)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Simonsen Metal Products Co., Ill (a, g)
Smoot-Holman Co., Calif (g)
Southern Metal Products Co., La (a,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,b,g)
Star Stamping Co., Mich (a,b,g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Stirrup Metal Products Corp., NJ (a, b,c,g)
Superior Spinning & Stamping Co., Ohio (a,b,f,g)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,f,g)
Teiner, Roland Co., Inc., Mass (a,b, c,f,g,h)
Thompson-Bremer & Co., Ill (a,b,c,f, g,h)
Titan Metal Mfg. Co., Pa (b)
Titanium Metals Corp. of America, NY (h)
Triangle Stamping Co., Ohio (a,b,c,d, f,g,j)
U.S. Steel Corp., Pa (g)
United-Carr Fastener Corp., Mass (a,b, g)
Van Huffel Tube Corp., Ohio (a,b,g)
Vanadium-Alloys Steel Co., Pa (f)
Vollrath Co., Wis (g)
Vulcan-Kidd Steel Div., H.K. Porter Co. Inc., Pa (g)
Waterbury Cos., Inc., Conn (a,b,g)
Waterbury Pressed Metal Co., Conn (a,b,f,g)
Waterman Industries, Inc., Calif (a,b, g)
Wayne Foundry & Stamping Co., Mich (a,b,e,g,h)
Wesbar Stamping Corp., Wis (a,b,c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,e,f,g)
Wisconsin Tool & Stamping Co., Ill (a,b,g)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (a)
Worcester Pressed Steel Co., Mass (a,b,c,e,f,g,h,j)
Worcester Stamped Metal Co., Mass (a,b,f,g,h,j)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Wycoff Steel Co., Pa (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Mfg., Inc., Ohio (a,g)

Drop Forgings

(see Forgings)

Ductile Iron

(see Iron)

Electrodes, Welding

(see Filler Metals)

Electroless Coatings

(see Immersion Coatings)

Electroplated Coatings

(Electroplaters; see also Preplated Metals)

A & A Die Casting Co., Calif
Abalon Precision Mfg. Corp., NY
Acme Plating Co., Ohio
Ainsworth Precision Castings Co., Div. of Harsco Corp., Mich —Ad p 344
Allied Research Products, Inc., Md —Ad p 281
Aluminum Billets, Inc., Ohio
American Emblem Co., Inc., NY
American Nickeloid Co., Ill
American Smelting & Refining Co., NY
Apollo Metal Works, Ill
Atlantic Brass Works, Inc., Ill
Atlantic Steel Co., Ga
Auld, D.L. Co., Ohio
Bart Mfg. Corp., NJ
Bethlehem Steel Co., Pa
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa
Brewer-Titchener Corp., NY
Brooks & Perkins, Inc., Mich Ad p 362
Campbell, A.S. Co., Inc., Mass
Chromium Corp. of America, NY
Cincinnati Pump & Mfg. Co., Inc., Ohio
City Plating Works, Inc., Conn
Cohan Epner Co., Inc., NY
Colonial Alloys Co., Pa

Letters in ( ) indicate materials and forms—turn page for key

Columbus Dental Mfg. Co., Ohio
Commercial Screw Products Co., Ohio
Conforming Matrix Corp., Ohio
Continental Die Casting Corp., Mich
Designers Metal Corp., Ill
Diamond Alkali Co., Ohio
Diversey Corp., Metal Industries Div., Ill
Dollin Corp., NJ
Du-Wel Metal Products, Inc., Mich
Eaton Mfg. Co., Reliance Div., Ohio
Edna Lite Optical Co., Inc., NY
Electric Auto-Lite Co., Ohio
Electric Materials Co., Pa
Electrolizing Corp., Ohio
Fox Co., Ohio
General Findings & Supply Co., Industrial Div., Mass
Grand Rapids Brass Co., Mich
Hardy Mfg. Corp., Ind
Harshaw Chemical Co., Ohio
Hilfinger Corp., Ohio
Hull, R.O. & Co., Inc., Ohio
Indium Corp. of America, NY
Industrial Chromium Corp., Mass
K. & L. Plating Co., Pa
Kees, F.D. Mfg. Co., Neb
La France Precision Casting Co., Pa
Lakeland Industries, Minn
Lea Mfg. Co., Conn
Litho-Strip Corp., M.M. Young Div., Ill
Lundquist Tool & Mfg. Co., Inc., Mass
MacDermid, Inc., Conn
Marlane Development Co., Inc., NY
Master Chrome Service, Inc., Ohio
Mechanical Plating Co., Ill
Medico Industries, Inc., Pa
Merrimac Brass, Mass
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metals & Controls Corp., Mass
Metaplast Process, Inc., NY
Michigan Chrome & Chemical Co., Mich
Modern Plating Corp., Ill
National Malleable & Steel Castings Co., Ohio
National-Standard Co., Mich
New Jersey Metals Co., NJ
New Jersey Zinc Co., NY
Norgren-Stemac, Inc., Colo
Olean Electro Plating Co., NY
Ormond Mfg. Co., Inc., NJ
Penn Metal Co., Inc., W. Va
Promat Div., Poor & Co., Ill
Reed & Prince Mfg. Co., Mass
Republic Steel Corp., Ohio
Reynolds Wire Div., National-Standard Co., Ill
Rustproofing & Metal Finishing Corp., Mass
St. Louis Diecasting Corp., Mo
Seal-Peel, Inc., Mich
Semon Bache & Co., NY
Sharon Steel Corp., Pa
Sommer Metalcraft Corp., Ind
Southern Metal Products Co., La
Spencer Nahm Co., Calif
Steel Protection & Chemical Co., Ind
Stevens, Frederic B., Inc., Mich
Stirrup Metal Products Corp., NJ
Sylvania Electric Products, Inc., Parts Div., Pa
Thermo Materials, Inc., Calif
Tiarco Corp., NJ
Tubular Rivet & Stud Co., Mass
Udylite Corp., Mich
United-Carr Fastener Corp., Mass
Vanamatic Co., Ohio
Van der Horst Corp., NY
Van Valkenburg, L.D. Co., Mass
WLS Stamping Co., Ohio
Wayne Foundry & Stamping Co., Mich
Wesbar Stamping Corp., Wis
Western Coating Co., Mich
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY
Williams Gold Refining Co., Inc., NY
Woodstock Div., Electric Auto-Lite Co., Ill
Worcester Wire Works Div., National-Standard Co., Mass
Worth Co., Wis
Zeller Corp., Ohio

Embossed Metals

(Incl. rigidized)

Aluminum Co. of America, Pa (a)
American Brass Co., Conn (b)
American Nickeloid Co., Ind. (a,b,g,j)
American Steel & Wire Div., U.S. Steel Corp., Ohio (g)
Ardmore Products, Inc., NJ (a,b,c,d,e,f,g,h,j)
Atlantic Steel Co., Ga (a,b,g)
Auld, D.L. Co., Ohio (a,b)
Biersach & Niedermeyer Co., Wis (a,b,g)
Clad Rex Corp., Ill (a,g)
Colonial Alloys Co., Pa (a)
Cooley, W.J. & Co., Tenn (a,b,c,g)
Copper & Brass Sales, Inc., Mich (a)
Croname Inc., Ill (a,b,g)
Electric Steel Foundry Co., Ore (a,b,c,g)
Fairmont Aluminum Co., Va (a)
Falstrom Co., NJ (a,b,e,f,g,h)
Grammes, L.F. & Sons, Inc., Pa (a,b,g)
Hawkridge Bros. Co., Mass (a)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Langsenkamp, F.H. Co., Ind (a)
Mahon, R.C. Co., Mich (a)
McKinney Mfg. Co., Pa (a,b,e,f,g)
Mechanical Steel Tubing Corp., NY (a,g)
Metal Goods Corp., Mo (a)
Morse, Fred W. Co., RI (a,b,c,g)
Olin Mathieson Chemical Corp., Aluminum Div., NY (a)
Parker Metal Goods Co., Mass (a,b,g)
Premier Metal Works, Inc., Ill (a,b,f,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Reynolds Metal Co., Ky (a)
Rigidized Metals Corp., NY (a,b,f,g,h)
Ryerson, Joseph T. & Son, Inc., Ill (a)
Sharon Steel Corp., Pa (g)
Southern Aluminum Finishing Co., Inc., Ga (a)
Southwestern Porcelain Steel Corp., Okla (g)
Sun Steel Co., Ill (a,g,h)
Wesbar Stamping Corp., Wis (a,b,c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Wilson-Hurd Mfg. Co., Inc., Wis (a)

Emulsion Coatings

(see Organic Coatings)

Enamels

(see Organic Coatings)

Epoxies

Adhesive Products Corp., NY (x)
Amercoat Corp., Calif (ee)
American Metaseal Corp., NJ (x,ee)
Angier Adhesives Div., Interchemical Corp., Mass (x)
Aries Laboratories, Inc., NY (p,x,y)
Armstrong Products Co., Ind (x)
Atlas Mineral Products Co., Pa (x)
Bakelite Co., Div. of Union Carbide Corp., NY (p,x)
Biggs, Carl H. Co., Inc., Calif (t,x,y)
Bisonite Co., Inc., NY (x)
Borden Chemical Div., Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (p,x,y)
Chemical Coatings & Engineering Co., Inc., Pa (p,x)
Chemical Development Corp., Mass (p,x)
Ciba Co., Inc., Plastics Div., Pa
(p,x)—Ad pp 212-13
Colonial Kolonite Co., Ill (bb,cc)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (x,y)
Dayton Rubber Co., Ohio (x,y)
Dennis Chemical Co., Mo (y)
Devcon Corp., Mass (x,y)
Dow Chemical Co., Plastics Div., Mich
(p)—Ad pp 189, 198
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Electrofilm, Inc., Calif (t)
Emerson & Cuming, Inc., Mass (p,u,x,bb)
Fiber Glass Industries, Inc., NY (x,y,cc)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (ee)
Formica Corp., Sub. of American Cyanamid Co., Ohio (cc,ee)
Foss Mfg. Co., Plastics Div., Id (p)
Fry Plastics Co., Calif (p,x)
Fuller, H.B. Co., Minn (x)
Furane Plastics, Inc., Calif (x,y)
Galigher Co., Utah (p,s,x)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)
General Plastics Mfg. Co., Wash (x)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Glo-Brite Products, Inc., Ill (u)
Hardman, H.V. Co., Inc., NJ (x,bb)
Heil Process Equipment Corp., Ohio (x)
Houghton Laboratories, Inc., NY (p,x,y,bb,cc,dd,ee)
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky (p,x)
Kish Industries, Inc., Mich (x)
Kurz, Kasch, Inc., Ohio (y)
Lewis, G.B. Co, Wis (bb)
Loven Chemical of California, Calif (p)
Maloney, F.H. Co., Tex (x,y)
Marblette Corp., NY (p,u,x,y,bb)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (cc)
Micarta Div., Westinghouse Electric Corp., SC (x,y)
Minneapolis Honeywell Regulator Co., Minn (p,u,x)
Narmco Resins & Coatings Co., Calif (u,x,y,dd)
National Vulcanized Fibre Co., Del (cc)
New England Laminates Co., Inc., Conn (cc)
Norrich Plastics Corp., NY (bb,cc,dd,ee)
Northern Plastics Corp., Wis (cc,dd)
Ohio Adhesives Corp., Ohio (x)
Panelyte Div., St. Regis Paper Co., NY (x,bb,cc,dd,ee)
Permacel-LePage's, Inc., NJ (p,x,y)
Philrus Products Co., NJ (bb,cc,dd,ee)
Poly Resins, Calif (p,x)
Polygon Plastic Co., Ind (ee)
Porter, William Co., Calif (cc,ee)
Pyrosil, Inc., Ohio (x,cc)
Quelcor, Inc., Pa (t)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x,cc)
Raybestos-Manhattan, Inc., Raybestos Div., Conn (x)
Reichhold Chemicals, Inc., NY (p,x)
Ren Plastics, Inc., Mich (p,s,x,y,ee)
Reynolds Chemical Products Co., Mich (p,x)
Rezolin, Inc., Calif (p,x)
Rogers Corp., Conn (y)
Schwartz Chemical Co., Inc., NY (x)
Shell Chemical Corp., NY (p)
Specialty Resins Co., Calif (x,y)
Strick Plastics Co., Pa (u,cc)
Sun Chemical Corp., Electro Technical Div., NJ (x)
Swedlow Plastics Co., Calif (cc)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Thermal Refractories Corp., NJ (u)
U.S. Gypsum Co., Ill (x)
U.S. Polymeric Chemicals, Inc., Conn (s)

Ethyl Cellulose

Ace Plastic Co., NY (bb,cc,dd,ee)
Adhesive Products Corp., NY (x)
American Hard Rubber Co. Div. of Amerace Corp., NJ (bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (t)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Auburn Plastics, Inc., NY (bb,dd,ee)
Bamberger, Claude P., Inc., NJ (y)
Campco Div., Chicago Molded Products Corp., Ill (t,cc)
Carroll, J.B. Co., Ill (cc)
Coating Products, Inc., NJ (t,cc)
Continental-Diamond Fibre Corp., Del (ee)
CrystalX Corp., Pa (bb,cc,dd,ee)
Davis, Joseph Plastics Co., NJ (t,y,bb,cc,dd,ee)
Denver Plastics, Inc., Colo (u)
Dow Chemical Co., Plastics Div., Mich
(p,y,cc)—Ad pp 189, 198
Falge Engineering Corp., Md (t)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
Gering Products, Inc., NJ (y,bb,dd)
Glass Laboratories, NY (bb,dd)
H & R Industries, Pa (bb,cc,dd,ee)
Hercules Powder Co., Del (p,y)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
K S H Plastics, Inc., Mo (bb,cc,dd)
Muehlstein, H. & Co., Inc., NY (y)
Nixon Nitration Works, NJ (bb,cc)
Omni Products Corp., NY (y,bb,cc)
Panelyte Div., St. Regis Paper Co., NY (cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Schwab Plastic Corp., Mich (bb,cc,dd,ee)
Simon Products Co., Ill (t)
Southern Plastics Co., SC (bb,cc,dd,ee)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,ee)
Western Felt Works, Ill (cc)
World Plastex, NY (bb,cc,dd)
World Plastics, NY (bb,cc,dd,ee)

Expanded Metals

Aluminum Co. of America, Pa (a)
American Metal Products, Inc., Ohio (g)
American Sheet Metal Works, Inc., Conn (a,b,g)
Atlantic Steel Co., Ga (g)
Biersach & Niedermeyer Co., Wis (a,b,c,f,g)
Clad-Rex Corp., Ill (a,g)
Colonial Alloys Co., Pa (a)
Designers Metal Corp., Ill (a,b,d,e,f,g,j)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Ellwood City Iron & Wire Co., Pa (c)
Evans, George Corp., Ill (a)
Flexonics Corp., Ill (g)
Hawkridge Bros. Co., Mass (a)
Hazledine, E.T. Co., Ind (g)
Houston Blow Pipe & Sheet Metal Works, Tex (g)
Ideal Can Co., Mass (g)
Kaiser Steel Corp., Calif (g)
Kees, F.D. Mfg. Co., Neb (g)
Levinson Steel Co., Pa (a,g)

Mechanical Steel Tubing Corp., NY (a,g)
Metal Goods Corp., Mo (g)
Penn Metal Co., Inc., Mass (a,b,c,d, f,g,h,j)
Republic Steel Corp., Ohio (g)
Reynolds Aluminum Supply Co., Ga (a, g)
Rolled Alloys, Inc., Mich (f)
Rolock Inc., Conn (f)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Standard Metals Corp., Mass (f)
Trojan Steel Co., W. Va (g)
U.S. Gypsum Co., Ill (a,g)
Vulcan Rail & Construction Co., NY (g)
Ward, H.H. Co., Pa (g)
Whitehead Metal Products Co., Inc., NY (a,f)
Whyte, Oliver Co., Inc., NY (a,g)
Wire & Iron Products, Inc., Mich (f,g)

Extrusions

(see below; also Impact Extrusions; Tubing)

Extrusions, Metallic

(excl. Tubing, Pipe)

Accurate Metal Weather Strip Co., Inc., NY (a,b)
Adams Engineering Co., Inc., Fla (a)
Aerolite Extrusion Co., Ohio (a)
Allegheny Ludlum Steel Corp., Pa (g)
Aluminum Co. of America, Pa (a,e)—Ad p 331
Aluminum Billets, Inc., Ohio (a)
Aluminum Extrusions, Inc., Mich (a)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Machine & Foundry Co., Ohio (g,h)
American Reed Co., Inc., Mass (e)
American Steel & Wire Div., U.S. Steel Corp., Ohio (g)
Ampco Metal, Inc., Wis (b)
Armco Steel Corp., Sheffield Div., Mo (g)
Arvin Industries, Inc., Ind (a)
Atlantic India Rubber Works, Inc., Ill (m)
Atlantic Steel Co., Ga (a)
Auld, D.L. Co., Ohio (a)
B & T Metals Co., Ohio (a)
Babcock & Wilcox Co., Tubular Products Div., Pa. (c,g)
Beck, I. & Sons, Inc., NY (a,b)
Belmont Aluminum Extrusion Co., Pa (a)
Benada Aluminum Products Co., Ohio (a)
Beryllium Corp., Pa (b)
Bohn Aluminum & Brass Corp., Mich (a,b)
Bonnell, William L. Co., Inc., Ga (a)
Bossert Div., Rockwell Spring and Axle Co., NY (g)
Bridgeport Brass Co., Conn (a,b,h)
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b)
Bristol Brass Corp., Conn (b)
Bunker Hill Co., Calif (d)
Burgess-Norton Mfg. Co., Ill (c)
Cameron Iron Works, Inc., Special Products Div., Tex (c,f,g)
Capital Products Corp., Pa (a)
Chase Brass & Copper Co., Conn (b,h)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Columbus Bolt & Forging Co., Ohio (a,b,g)
Consolidated Fruit Jar Co., NJ (d)
Copper & Brass Sales, Inc., Mich (a, b,e)
Corson Industries, Pa (a)
Craft Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Crown Metal Co., Wis (d)
Curtiss-Wright Corp., Metals Processing Div., NY (f,g,h)
Cyril Bath Co., Ohio (a,h)
Detroit Gasket & Mfg. Co., Extruded Metals Div., Mich (a)
Division Lead Co., Ill (d)
Dixie Aluminum Corp., Ga (a)
Dixie Bronze Co., Ala (b)
Dow Chemical Co., Magnesium Div., Mich (e)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (f,g)
Empire Metal Co., NY (d)
Etched Products Corp., NY (a)
Eureka Electric Products Co., Pa (b)
Fletcher Enamel Co., W. Va (a,b,c,d, e,f)
Flynn, Michael Mfg. Co., Pa (a)
Frasse, Peter A. & Co., Inc., NY (g)
Fromson Orban Co., Inc., NY (a)
Fuller, W.P. & Co., Calif (j)
Garlock Packing Co., NY (k,m)
General Extrusions, Inc., Ohio (a)—Ad p 342
Harvey Aluminum Div., Harvey Machine Co., Inc., Calif (a,g,h)
Hawkridge Bros. Co., Mass (a)
Himmel Bros. Co., Conn (a)
Hokin Aluminum Co., Ill (a)
Hunter Douglas Aluminum Div., Bridgeport Brass Co., Calif (a,b)
International Nickel Co., Inc., NY (f)
Jarl Extrusions, Inc., NY (a)—Ad p 348
Jasco Aluminum Products Co., NY (a)
Jet Specialties Co., Inc., Calif (k)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kawneer Co., Mich (a)
Kidd Drawn Steel Co., Pa (g)
Kroh Wagner, Ill (a)
Langsenkamp, F.H. Co., Ind (a)
Light Metals Corp., Mich (a)
Magnode Products, Inc., Ohio (a,e)
Metal Goods Corp., Mo (a)
Metal Trims, Inc., Miss (a)
Moczik Tool & Die Works, Mich (a,b)
Monarch Tool & Mfg. Co., Ky (a)
National Aluminum Co., Ohio (a)
National Lead Co., NY (a,b,d)
National Metal Products Co., Pa (a,b)
National Vulcanized Fibre Co., Del (k)—Ad p 225
New Jersey Aluminum Extrusion Co., Inc., NJ (a)
Olin Mathieson Chemical Corp., Aluminum Div., NY (a)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Penn Brass & Copper Co., Pa (a)
Penn Extrusion Corp., Pa (a)
Pfister Aluminum Corp., NJ (a)
Phelps Dodge Copper Products Corp., Pa
Pioneer Aluminum, Inc., Calif (a)
Precision Extrusions, Inc., Ill (a)
Raybestos-Manhattan, Inc., NJ (k,m)
Republic Metals Co., Inc., NY (d)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a, b)
Reynolds Aluminum Supply Co., Ga (a)
Reynolds Metals Co., Va (a)
Rockwell-Standard Corp., Stamping Div., NY (g)
Royce Aluminum Corp., Mass (a)
Ryerson, Joseph T. & Son, Inc., Ill (a)
Saramar Aluminum Co., Ohio (a)
Scaife Co., Pa (b,c,f,g)
Scovill Mfg. Co., Conn (b)
Serrick Corp., John Lees Div., Ind (a,g)
Southern Aluminum Finishing Co. Inc., Ga (a)
Stainless Metals, Inc., NY (g)
Steel Industries, Inc., Ind (b,g)
Superior Industries, Inc., Ohio (a)
Supplex Co., Div. of Amerace Corp., NJ (k)
Texas Aluminum Co., Inc., Tex (a)
Textron Metals Co., Ohio (a)
Thompson Products, Inc., Light Metals Div., Ohio (a)
Thompson Products, Inc., Valve Div., Ohio (f,g)
Titan Metal Mfg. Co., Pa (b)
Titanium Metals Corp. of America, NY (h)
Toledo Stamping & Mfg. Co., Ohio (a,g)
Trim Alloys, Inc., Mass (a)
United Shoe Machinery Corp., Mass (f,g)
U.S. Extrusions Corp., NY (a)
U.S. Steel Corp., Pa (g)
Universal Converting Corp., Mass (a)
Uniworld Research Corp. of America, Ohio (c)
Vulcan Metal Products, Inc., Ala (a)
Vulcan Rail & Construction Co., NY (a)
W.F. Mfg. Co., Calif (a)
Warner Mfg. Corp., NJ (a)
Werner, R.D. Co, Inc., NY (a)—Ad p 346
Wesbar Stamping Corp., Wis (a,b,c,g)
White Metal Rolling & Stamping Co., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a)
Wilde Tool Co., Inc., Kan (g)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (a)
Worcester Pressed Steel Co., Mass (a, g)
Youngstown Kitchens Div., American Standard Co., Ohio (g)
Youngstown Mfg., Inc., Ohio (a)

Extrusions, Nonmetallic

(excl. Tubing, Pipe)

Ace Plastic Co., NY (k)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
Amco Plastic Pipe Co., Calif (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Molding Co., Calif (k)
American Plastics Corp., NY (k)
Anchor Plastics Co., Inc., NY (k)—Ad p 340
Anesite Co., Ill (l)
Atlas Mineral Products Co., Pa (k)
Auburn Mfg. Co., Conn (k,m)
Auburn Plastics, Inc., NY (k,m)
Automotive Rubber Co., Inc., Mich (m)
Beck, I. & Sons, Inc., NY (m)
Bond International, Inc., Mich (m)
Borden Co., Borden Chemical Div., NY (k)
Borden Chemical Co., Resinite Dept., Calif (k)
Bowling Green Rubber Co., Ohio (m)
Brown Rubber Co., Inc., Ind (m)
Button Corp. of America, NJ (k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Campco Div., Chicago Molded Products Corp., Ill (k)
Canfield, H.O. Co., Va
Capac Industries, Inc., Mich (k)
Carlon Products Corp., Ohio (k)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (k)
Celluplastic Corp., NJ (k)
Chardon Rubber Co., Ohio (k)
Chippewa Plastics, Inc., Wis (k)
Colonial Plastics Mfg. Co., Ohio (k)
Conneaut Rubber & Plastics Co., Ohio (k,m)
Connecticut Hard Rubber Co., Conn (m)—Ad p 205
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Div. of Budd Co., Del (k)
Contour Extrusion Co., NY (k)
Crescent Plastics, Inc., Ind (k)
Davis, Joseph Plastics Co., NJ (k)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Eberhard Faber Pencil Co., NY (m)
Eclipse Plastic Industries, Inc., Fla (k)
Electric Auto-Lite Co., Ohio (k)
Eljay Corp., Md (l)
Enflo Corp., NJ (l)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Extruders, Inc., Calif (k)
Faultless Rubber Co., Ohio (m)
Frost Rubber Co., Ill (m)
Fry Plastics Co., Calif (k)
Galigher Co., Utah (k)
Garlock Packing Co., NY (k,m)—Ad p 361
Geauga Industries Co., Ohio (k,m)
General American Transportation Corp., Ill (k)
General Electric Co., Chemical & Metallurgical Div., Ill (k)
General Gasket, Inc., Conn (m)
General Plastics Corp., Ohio (k)
Gering Products, Inc., NJ (k)
Glass Laboratories, Inc., NY (k)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Gotham Plastics Corp., NY (k)
H & R Industries, Pa (k,m)
Hall Mfg. Co., NJ (k)
Hartwell, H.N. & Sons, Inc., Mass (k)
Haveg Industries, Inc., Del (l)
Hawkeye Rubber Mfg. Co., Iowa (k)
Hewitt Rubber Div., Hewitt-Robins, Inc., NY (m)
Hungerford Plastics Corp., NJ (k,m)
Hydrawlik Co., NJ (k,m)
Industrial Plastics Corp., Ind (k)
Irvington Varnish & Insulation Div., Minnesota Mining & Mfg. Co., NJ (k)
Jet Specialties Co., Inc., Calif (k)
Johnson Plastic Corp., Ohio (k,m)
Johnson Rubber Co., Ohio (m)
Jordan-Rogers Co., Calif (k)
Joymont Plastics, Inc., Ohio (k)
Judsen Rubber Works, Inc., Ill (m)
K S H Plastics, Inc., Mo (k)
Kaykor Industries, Inc., NJ (k)
Keystone Plastics, Inc., NJ (k)
Kraloy Plastic Pipe Co., Inc., Calif (k)
Lewis, G.B. Co., Wis (l)
Luminous Resins, Inc., Ill (k)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
Maloney, F.H. Co., Tex (k,m)
Martin Rubber Co., Inc., NJ (m)
Mayon Plastics, Minn (k)
Mechanical Rubber Products Co., NY (l)
Meyer, J. & Sons, Inc., Pa (k)
Mid-States Rubber Products, Inc., Ind (m)
Midwest Plastic Products Co., Ill (k)
Minnesota Rubber Co., Minn (l,m)
Minnesota Rubber & Gasket Co., Minn (m)
Moldex, NY (m)
Moore, Samuel & Co., Ohio (k)
Multiple Extrusions, Inc., Minn (m)
Munray Products Div., Fanner Mfg. Co., Ohio (k)
National Gasket & Washer Mfg. Co., Inc., NY (k,l,m)
National Tube Div., U.S. Steel Corp., Pa (k)
National Vulcanized Fibre Co., Del (k)—Ad p 190
New England Tape Co., Inc., Mass (k)
Panelyte Div., St. Regis Paper Co., NY (k)
Parker, Stearns & Co., Inc., NY (m)
Pawling Rubber Corp., NY (k,l)
Perfex Plastics, Inc., Ill (k,m)
Pipco International Corp., Sub. of Plastiglide Mfg. Corp., Calif (k)
Plastex Co., Ohio (k)
Plastic Engineering, Inc., Ohio (k)
Plastic Packaging Co., Ill (k)
Polyform Plastics Corp., NY (k)
Polygon Plastic Co., Ind (l)
Polymer Corp. of Pennsylvania, Pa (k)
Polyplastic Products, Inc., NJ (k)
Prima Pipe Co., Tex (k)
Prince Rubber Co., Inc., NY (k,m)
Pyramid Plastics, Inc., Ill (k)
Quaker Rubber Div., H.K. Porter Co., Pa (k,m)
Raybestos-Manhattan, Inc., NJ (l,m)
Reliance Plastic & Chemical Corp., NJ (k)
Resin Industries, Calif (k)
Resistoflex Corp., NJ (k)
Rex Corp., Mass (k)
Robot Devices, Inc., Va (k)
Rogers Corp., Conn (m)
Rowland Products, Inc., Conn (k)
Ryerson, Joseph T. & Son, Inc., Ill (k)
Schwab Plastic Corp., Mich (k,m)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Ind (k)
Sheller Mfg. Corp., Mich (k,l,m)
Southern Plastics Co., SC (k,m)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Stalwart Rubber Co., Ohio (m)
Standard Products Co., Mich (m)
Stockwell Rubber Co., Inc., Pa (k,m)
Sun Rubber Co., Ohio (m)
Sunlites Plastics, Inc., Wis (k)
Superior Plastics, Inc., Ill (k)
Supplex Co., Div. of American Hard Rubber Co., NJ (k,m)
Technical Specialties Co., NY (m)
Textron Metals Co., Ohio (k)
Thombert, Inc., Iowa (k)
Tri-Point Mfg. & Developing Co., NY (k)
United Shoe Machinery Corp., Mass (k,m)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
U.S. Stoneware Co., Ohio (k,l,m)
Victory Plastics Co., Mass (k)
Vogt Mfg. Co., NY (k)
Vulcanized Rubber & Plastics Co., Pa (m)
Western Felt Works, Ill (l,m)
Western Plastics Corp., Neb (k)
Westlake Plastics Co., Pa (k)
World Plastex, NY (k,m)
World Plastics, NY (k)

Fabrics, Nonwoven Synthetic

American Felt Co., Conn —Ad p 245
Beckmann, Inc., NY
Booth Felt Co., Inc., NY
Cadillac Plastic & Chemical Co., Mich
Chicopee Mills, Inc., NY
Continental Felt Co., NY
Dexter, C.H. & Sons, Inc., Conn
Electrofilm Inc., Calif
Felters Co., Mass —Ad p 254
Ferro Corp., Fiber Glass Div., Tenn
Filpaco Industries, Inc., Ill
Foss Mfg. Co., Id
Gustin-Bacon Mfg. Co., Mo
Kendall Co., Kendall Mills Div., Mass
Masland Duraleather Co., Pa
National Felt Co., Mass
Quaker City Felt Co., Pa
Russell Mfg. Co., Conn
Snyder, M.L. & Son, Inc., Pa
Star Woolen Co., NY
Stevens, J.P. & Co., Inc., NY
Tallman-McCluskey Fabrics Co., Mo
Troy Blanket Mills, NY
U.S. Plywood Corp., NY
Visking Corp., Fabrics Div., Ark
Wellington Sears Co., NY
Wood Conversion Co., Minn

Fabrics, Woven

(coated)

Alpha Wire Corp., NY
Cadillac Plastic & Chemical Co., Mich
Connecticut Hard Rubber Co., Conn —Ad p 205
Continental-Diamond Fibre Corp., Del
Cordo Chemical Corp., Conn
du Pont de Nemours, E.I. & Co., Inc., Del
Goodrich, B.F. Industrial Products Co., Ohio
National Gasket & Washer Mfg. Co., Inc., NY
Russell Mfg. Co., Conn
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio

Fabrics, Woven

(uncoated)

Aetna Felt Co., Inc., NY
Alox Mfg. Co., Mo
Alpha Wire Corp., NY
Atlantic Bag Co., NY
Booth Felt Co., Inc., NY
Cadillac Plastic & Chemical Co., Mich
Electrofilm, Inc., Calif
Ferro Corp., Fiber Glass Div., Tenn
Foss Mfg. Co., Plastics Div., Id
Franklin Cotton Mill Co., Ohio
General Asbestos Gasket Mfg. Corp., Mo
Industrial Rayon Corp., NY
Kendall Mills Div., Kendall Co., Mass
National Gasket & Washer Mfg. Co., Inc., NY
Russell Mfg. Co., Conn
Stevens, J.P. & Co., Inc., NY
Supreme Industrial Products Co., Ill
Tallman-McCluskey Fabrics Co., Mo
Thompson, H.I. Fiber Glass Co., Calif
Turner Halsey Co., NY
Twitchell, E.W., Inc., Pa
U.S. Rubber Co., NY
Vulcan Rubber Products Div., Reeves Bros., Inc., NY
Wellington Sears Co., NY

Felts, Synthetic

(see Fabrics, Nonwoven)

Felts, Wool

Aetna Felt Co., Inc., NY
American Felt Co., Conn —Ad p 245
Armstrong Cork Co., Pa
Artex Felt Co., NY
Bacon Felt Co., Mass
Beckmann, Inc., NY
Booth Felt Co., Inc., NY
Boston Felt Co., Mass
Carey, Philip Mfg. Co., Ohio
Central Felt & Fabrics Corp., NY
Coated Abrasive Products, Inc., Ohio
Continental Felt Co., NY —Ad p 250
Felters Co., Mass —Ad p 254
Fidelity Felt & Mfg. Co., NY
Filpaco Industries, Inc., Ill
General Gasket, Inc., Conn
Johns-Manville Corp., NY
Mechanical Felt & Textiles Co., NJ
National Felt Co., Mass
National Gasket & Washer Mfg. Co., Inc., NY
Quaker City Felt Co., Pa
Standard Asbestos Mfg. Co., Ill
Standard Felt Co., Calif
Supreme Industrial Products Co., Ill
Wellington Sears Co., NY
Western Felt Works, Ill —Ad p 249
Wood Conversion Co., Minn

Ferrites

(see Ceramics)

Fibers, Synthetic

(see specific polymer)

Filler Metals, Welding

(electrodes, rods, etc.)

Abalon Precision Mfg. Corp., NY
Acme Stamping & Mfg. Co., Pa
Acorn Sheet Metal Mfg. Co., Inc., Ill
Alloy Rods Co., Pa
All-State Welding Alloys Co., Inc., NY
American Manganese Steel Div., American Brake Shoe Co., Ill
American Products Corp., Ill
American Sheet Metal Works, Inc., Conn
Arcos Corp., Pa
Champion Rivet Co., Ohio —Ad p 398
Electric Steel Foundry Co., Ore
Eutectic Welding Alloys Corp., NY
General Dynamics Corp., Liquid Carbonic Div., Ill
Harnischfeger Corp., Wis
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Ideal Can Co., Mass
Ingersoll Products Div., Borg-Warner Corp., Ill
International Nickel Co., Inc., NY
Kaiser Aluminum & Chemical Sales, Inc., Ill
King, Alfred B. Co., Conn
Lincoln Electric Co., Ohio
Linde Co., Div. of Union Carbide Corp., NY —Ad p 400
Lukens Steel Co., Pa
Magnesium Co. of America, Ind
Magnesium Products of Milwaukee, Inc., Wis
Magnesium Elektron, Inc., NY
Manganese Steel Forge Co., Pa
Marquette Mfg. Co., Inc., Minn
McDowell Mfg. Co., Pa
Metal Goods Corp., Mo
Metal & Thermit Corp., NJ
Midwest Stamping & Mfg. Co., Ohio
Morrisville Foundry Co., Inc., Vt
Narragansett Boiler Works, Inc., RI
Somerset Foundry & Machine Co., Pa
Southern Metal Products Co., La
United Wire & Supply Corp., RI
Victor Equipment Co., Calif
Wall Colmonoy Corp., Stainless Process Div., Mich
Waterman Industries, Inc., Calif
Wesbar Stamping Corp., Wis
Whitehead Metal Products Co., Inc., NY

Film

(see specific plastic or rubber)

Fluorocarbon Plastics

aaRBee Plastic Co., Calif (y)
Acme Resin Corp., Ill (p)
Allegheny Plastics, Inc., Pa (bb,cc,dd)
Allied Chemical Corp., General Chemical Div., NY (p)
Automotive Rubber Co., Inc., Mich (y, cc)
Bakelite Co., Div. of Union Carbide Corp., NY (p)
Bamberger, Claude P., Inc., NJ (y)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Chicago Gasket Co., Ill (t,bb,cc,dd,ee)
Colonial Kolonite Co., Ill (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)—Ad p 182
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Crane Packing Co., Ill (t,bb,cc,dd,ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Dixon Corp., RI (y,bb,cc,dd,ee)
Dodge Fibers Corp., NY (s,t,cc,dd)

du Pont de Nemours, E.I. & Co., Inc., Del (p,s)
du Pont de Nemours, E.I. & Co., Inc., Polychemicals Dept., Del (y)—Ad pp 195, 214-215
du Pont de Nemours, E.I. & Co., Inc., Textile Fibers Div., Del (s)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Enflo Corp., NJ (t,bb,cc,dd,ee)
Firestone Plastics Co., Pa (p)
Flexrock Co., Pa (bb,cc,dd,ee)
Galigher Co., Utah (bb,cc,dd,ee)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
General Gasket, Inc., Conn (t,cc)
General Plastics Corp., NJ (t)
General Plastics Mfg. Co., Wash (bb,cc,dd,ee)
H & R Industries, Pa (bb,cc,dd,ee)
Haveg Industries, Inc., Del (bb,cc,ee)
Hitemp Wires, Inc., NY (ee)
Insulation Mfrs. Corp., Ill (t,bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (y)
Minnesota Mining & Mfg. Co., Minn (y)
Norrich Plastics Corp., NY (bb,ee)
Permacel-LePage's, Inc., NJ (t,cc,ee)
Polymer Corp. of Pennsylvania, Pa (t,bb,cc,dd,ee)
Raybestos-Manhattan, Inc., Plastic Products Div., NJ (bb,cc,dd)
Resistoflex Corp., NJ (bb,cc,ee)
Russell Mfg. Co., Conn (s)
Sanford Plastics Corp., NY (bb,ee)
Shamban, W.S. & Co., Calif (p,t,x,y,bb,cc,dd,ee)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (t,y,bb,cc,dd,ee)
Staver Co., Inc., NY (cc,dd)
Thombert, Inc., Iowa (bb,cc,dd,ee)
Tri-Point Mfg. & Developing Co., NY (bb)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (t,bb,cc,dd,ee)
U.S. Stoneware Co., Ohio (ee)
Visking Corp., Plastics Div., Ind (t)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (bb,dd,ee)
Westlake Plastics Co., Pa (t,y,bb,cc,dd,ee)

Fluorocarbon Rubber

(fluoroelastomers)

Allis Rubber Div., Chicago-Allis Mfg. Corp., Ill (p)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Colonial Rubber Co., Ohio (y,cc,dd)
Connecticut Hard Rubber Co., Conn (bb,cc,dd,ee)
Continental Rubber Works, Pa (bb,cc,dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dixon Corp., RI (y,bb,cc,dd,ee)
Dodge Fibers Corp., NY (s,t,cc,dd)
Dow Corning Corp., Mich (p)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (cc)
du Pont de Nemours, E.I. & Co., Inc., Elastomer Chemicals Div., Del (p)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Flexible Tubing Corp., Conn (ee)
Flexrock Co., Pa (bb,cc,dd,ee)
Garlock Packing Co., NY (y,cc)
Hitemp Wires, Inc., NY (ee)
Hooker Chemical Corp., NY (p)
Johns-Manville Corp., Dutch Brand Div. NY (cc)
Maloney, F.H. Co., Tex (y)
Minnesota Mining & Mfg. Co., Minn (p)
Norrich Plastics Corp., NY (bb,dd,ee)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Rogers Corp., Conn (u,y)
Russell Mfg. Co., Conn (s)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Co., Ill (y,cc,dd,ee)
Westlake Plastics Co., Pa (bb,cc,dd)

Foams

(see specific plastic or rubber)

Foil

(see specific metal)

Forgings

(see also Cold Headed Parts)

Abegg & Reinhold Co., Calif (g)
Accurate Brass Corp., NY (b)
Alco Products, Inc., NY (g)
Allegheny Ludlum Steel Corp., Pa (g)
Aluminium Ltd. Sales, Inc., NY (a)
Aluminum Co. of America, Pa (a,e)—Ad p 331
Amalgamated Steel Corp., Ohio (g)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Car & Foundry Div., ACF Industries, Inc., NY (g)
American Chain & Cable Co., Pa (g)
American Forge & Mfg. Co., Pa (g)
American Manganese Bronze Co., Pa (b)
American Steel Foundries, Ill (g)
Amforge Div., American Brake Shoe Co., Ill (a,g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armco Steel Corp., Sheffield Div., Mo (g)
Atlas Drop Forge Co., Mich (c,f,g,h)
Auld, D.L. Co., Ohio (a)
Baldt Anchor, Chain & Forge Div., Boston Metals Co., Pa (a,b,g)
Bay City Forge Co., Pa (g)
Bethlehem Steel Co., Pa (c,g)
Billings & Spencer Co., Conn (a,b,g,h)
Bingham Herbrand Corp., Herbrand Div., Ohio (g)
Blakeslee Forging Co., Conn (a,b,c,d,f,g,h)
Bohn Aluminum & Brass Corp., Mich (a,b)
Brewer-Titchener Corp., NY (a,g)
Bridgeport Brass Co., Conn (a,b,h)
Bristol Brass Corp., Conn (b)
California Drop Forge Co., Calif (g)
Cameron Iron Works, Inc., Special Products Div., Tex (c,f,g)—Ad p 339
Canton Forge & Axle Works, Poor & Co., Ohio (f,g)
Carbo Tool & Die Co., Ohio (c,f)
Carpenter Steel Co., Pa (f,g)
Castle, A.M. & Co., Ill (g)
Champion Rivet Co., Ohio (b,c,g)—Ad p 398
Chase Brass & Copper Co., Conn (b)
Chicago Extruded Metals Co., Ill (b)
Cincinnati Forging Co., Ohio (b)
Clapp, E.D. Mfg. Co., NY (b,c,f,g)
Cleveland Cap Screw Co., Ohio (a,b,f,g,h)
Cleveland City Forge Co., Ohio (a,c,f,g,h)
Cleveland Hardware & Forging Co., Ohio (g)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (c,g)
Columbus Bolt & Forging Co., Ohio (g)
Commercial Shearing & Stamping Co., Ohio (g)
Composite Forgings, Inc., Mich (g)
Copper & Brass Sales, Inc., Mich (a,b)
Crucible Steel Co. of America, Titanium and Vacuum Metals Product Div., Pa (b,c,f,g,h)
Curtiss-Wright Corp., Metals Processing Div., NY (a,b,f,g)—Ad p 363
Cyril Bath Co., Ohio (a,g)
Dirilyte Co. of America, Inc., Ind (a,b,e)
Edgcomb Steel & Aluminum Corp., NJ (g)
Electric Auto-Lite Co., Ohio (c)
Electric Materials Co., Pa (b)
Electric Steel Foundry Co., Ore (f,g)
Endicott Forging & Mfg. Co., Inc., NY (b,f,g,h)
Eureka Electric Products Co., Pa (a,b,g)
Fairmount Tool & Forging, Inc., Sub. of Houdaille Industries, Inc., Ohio (g)
Frasse, Peter A. & Co., Inc., NY (a,g)
Fromson Orban Co., Inc., NY (a)
Garden State Forge Co., NJ (a,b,c,f,g,h)
Giant Grip Mfg. Co., Wis (a,g,h)
Greene, G.G. Corp., Pa (g)
Harvey Aluminum Div., Harvey Machine Co. Inc., Calif (a,e,g)
Heppenstall Co., Pa (g,h)
Hobbs, Clinton E. Co., Mass (c,g)
Hunter-Douglas Aluminum Div., Bridgeport Brass Co., Calif (a,b)
Huron Forge & Machine Co., Mich (a,b,g)
Illinois Forge, Inc., Ill (g)
Illinois Iron & Bolt Co., Ill (g)
Indiana Forge & Machine Co., Ind (g)
International Nickel Co., Inc., NY (f)
Irwin Foundry & Mine Car Co., Pa (g)
Isaacson Iron Works, Wash (g)
Janney Cylinder Co., Pa (b)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Keystone Forging Co., Pa (g)
Kovar, John R. Mfg. Co., Inc., Minn (g)
Kropp Forge Co., Ill (g,h)
Ladish Co., Wis (a,b,c,e,f,g,h)
Larson, Charles E. & Sons, Inc., Ill (a,b,c,g)
Larson Tool & Stamping Co., Mass (a,b,c,e,f,g,h,j)
Latrobe Steel Co., Pa (g)
Lenape Hydraulic Pressing & Forging Co., Pa (a,b,g)
Lindell Drop Forge Co., Mich (g)
Machinery Forging Co., Ohio (g)
Mallory, P.R. & Co., Inc., Ind (b)
Manganese Steel Forge Co., Pa (g)
McCarter Iron Works, Inc., Pa (g)
McInnes Steel Co., Pa (f,g,h)
McNally Pittsburg Mfg. Co., Kan (g)
Melling Forging Co., Mich (f)
Midvale-Heppenstall Co., Pa (c,f,g)
Milwaukee Forge & Machine Co., Wis (g)
Montague Machine Co., Mass (g)
Moore Dry Dock Co., Calif (g)
Mueller Brass Co., Mich (a,b)—Ad p 357
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works, Inc., NJ (a,b,g)
National Cored Forging Div., Bridgeport Brass Co., Conn (a,b)
National Forge & Ordnance Co., Pa (g)
National Lead Co., NY (a,b,h)
National Supply Co., Industrial Products Div., Calif (g)
Norcross, C.S. & Sons Co., Ill (g)
Ohio Forge & Machine Corp., Ohio (c,f,g)
Olderman Mfg. Corp., Conn (b)
Olds Alloys Co., Calif (b)
Pacific States Steel Corp., Calif (g)
Park Drop Forge Co., Ohio (g)
Pattin Mfg. Co., Ohio (g)
Pencoyd Steel & Forge Corp., Pa (c,g)
Peninsular Steel Co., Mich (g)
Pettibone Mulliken Corp., Ill (g)
Pittsburgh Forgings Co., Pa (a,f,g)
Poor & Co., Canton Forge & Axle Works, Ohio (g)
Porter, H.K., Inc., Mass (g)
Porter, H.K., Inc., Forge & Fittings Div., Ohio (a,g)
Rankin Forge Co., Pa (c,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (a,b)
Rhode Island Tool Co., RI (a,b,e,g)—Ad p 342
Rockford Bolt & Steel Co., Ill (g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
St. Pierre Chain Corp., Mass (a,f,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Searjeant Metal Products, Inc., NJ (g)
Seltzer, George H. & Co., Pa (g)
Sharpsville Steel Fabricators, Inc., Pa (g)
Sherman & Reilly, Inc., Tenn (a,g)
Skookum Co., Inc., Ore (g)
Smith-Armstrong Forge, Inc., Ohio (g)
Standard Forge & Axle Co., Inc., Ala (g)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)
Star Heel Plate Co., Inc., NJ (g)
Steel, R. & Sons, Inc., NY (f,g)
Steel Improvement and Forge Co., Ohio (a,g)
Struthers Wells Corp., NY (f,g)
Taylor Forge & Pipe Works, Ill (a,c,f,g,h)
Thompson Products, Inc., Valve Div., Ohio (f,g)
Titan Metal Mfg. Co., Pa (a,b)
Tool & Mfg. Co., Inc., Pa (g)
Transue & Williams Steel Forging Corp., Ohio (b,c,f,g,h)
Tube Turns, Ky (a,b,c,f,g,h)
Union Forging Co., NY (g)
United Forge Co., Mich (c,g)
United Shoe Machinery Corp., Mass (a)
U.S. Steel Corp., Pa (g)
Universal-Cyclops Steel Corp., Pa (f,g)
Uniworld Research Corp. of America, Ohio (c)
Vanadium-Alloys Steel Co., Pa (c,g)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (g)
Walker Forge, Inc., Wis (g)
Weatherhead Co., Ind (a,b,g,h)
Weber-Knapp Co., NY (a)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Wilcox Forging Corp., Pa (e,f,g,h)
Wilde Drop Forge & Tool Co., Inc., Mo (g)
Williams, J.H. & Co., NY (a,b,f,g,h)
Wyman-Gordon Co., Mass (a,e,f,g,h)
Zeller Corp., Ohio (g)
Ziv Steel & Wire Co., Ill (g)

Forsterite

(see Ceramics)

Furanes

Adhesive Products Corp., NY (x)
Atlas Mineral Products Co., Pa (p,x)
Booty Resineers, Inc., NJ (p)
Catalin Corp. of America, NY (p)

Letters in ( ) indicate materials and forms—turn page for key

Durez Plastics Div., Hooker Chemical Corp., NY (p)
Electro Chemical Engineering & Mfg. Co., Pa (cc)
Foss Mfg. Co., Plastics Div., Id (p)
Furane Plastics, Inc., Calif (p,x)
Haveg Industries, Inc., Del (p,bb,cc, ee)
Knight, Maurice A., Ohio (p,x)
Loven Chemical of California, Calif (p)
Plastics Engineering Co., Wis (p)
Reichhold Chemicals, Inc., NY (p)
U.S. Stoneware Co., Ohio (y)

Galvanized Metals

(see Precoated Metals)

Galvanizers

Acme Galvanizing Co., Calif
Advance Galvanizing Co., Calif
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
American Smelting & Refining Co., NY
American Tinning & Galvanizing Co., Pa
Armco Steel Corp., Ohio
Armor Galvanizing Works, Inc., Calif
Atlantic Steel Co., Ga
Atlas Galvanizing Co., Calif
Bessemer Galvanizing Works, Ala
Boyles Galvanizing & Plating Co., Tex
Buffalo Steel Corp., NY
Cincinnati Pump & Mfg. Co., Inc., Ohio
Clayton & Lambert Mfg. Co., Ky
Clifton Conduit Co., Inc., Md
Columbian Steel Tank Co., Mo
Continental-Emsco Co., Calif
Debevoise Co., NY
Designers Metal Corp., Ill
Detroit Brass & Malleable Co., Mich
Dow Chemical Co., Tex
Empire Metal Co., NY
Enterprise Galvanizing Co., Pa
Fanner Mfg. Co., Ohio
Farrelloy Co., Pa
Fenestra, Inc., Mich
Green-Walker Galvanizing Co., Inc., La
Gregory, Thomas Galvanizing Works, NY
Hanlon-Gregory Galvanizing Co., Pa
Haywilk Galvanizing, Inc., La
Hill, James Mfg. Co., RI
Illinois Edison Porcelain Div., McGraw-Edison Co., Ill
Independent Galvanizing Co., NJ
Joslyn Mfg. & Supply Co., Ill
Joslyn Pacific Co., Calif
Kent County Galvanizing Co., RI
Kinkead Industries, Inc., Ill
Kobel, W.R. Sheet Metal Products, Utah
Koven, L.O. & Bro., Inc., NJ
Lawson, F.H. Co., Ohio
Lehigh Structural Steel Co., Pa
Lewis Bolt & Nut Co., Minn
Line Material Industries, McGraw-Edison Co., Pa
Los Angeles Galvanizing Co., Calif
Malleable Iron Fittings Co., Conn
Maze, W.H. Co., Ill
Metal Coating Corp., Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metalplate Co., Inc., Ala
Missouri Rolling Mill Corp., Miss
National Galvanizing Co., Pa
National Gasket & Washer Mfg. Co., Inc., NY
National Telephone Supply Co., Ohio
National-Standard Co., Mich
New Jersey Zinc Co., NY
Noland Tank & Galvanizing Co,, Tenn
Northwestern Steel & Wire Co., Ill
Nowery J. Smith Bolt & Supply Co., Tex
Penn Metal Co., Inc., W.Va
Pennsylvania Range Boiler Co., Pa
Promat Div., Poor & Co., Ill
Reed & Prince Mfg. Co., Mass
Republic Steel Corp., Ohio
Reynolds Wire Div., National-Standard Co., Ill
Riverside Foundry & Galvanizing Co., Mich
Roebling's, John A. Sons Corp., NJ
Rohnco, Inc., Ill
Ryerson, Joseph T. & Son, Inc., Ill
San Francisco Galvanizing Works, Calif
Sawhill Tubular Products, Inc., Pa
Scaife Co., Pa
Schlueter Mfg. Co., Mo
Sealube Co., Mass
Sharon Steel Corp., Pa
Sherman & Reilly, Inc., Tenn
Southern Galvanizing Co., Md
Southern Metal Products Co., La
Spencer Nahm Co., Calif
Stevens, Frederic B., Inc., Mich
Superior-Pacific Galvanizing Co., Calif
WLS Stamping Co., Ohio
Wessels Co., Mich
Wilcox-Crittenden Div., North & Judd Mfg. Co., Conn
Witt Cornice Co., Galvanizing Div., Ohio
Wood, John Co., Ill
Worcester Wire Works Div., National-Standard Co., Mass
Young & Greenawalt, Ind

Germanium

American Metal Climax, Inc., NY (o,w,aa)
American Zinc Sales Co., Mo (q)
Belmot Smelting & Refining Works, Inc., NY (aa)
Eagle-Picher Co., Ohio (w,aa)
Hardy, Charles, Inc., NY (aa)
Parker Metal Goods Co., Mass (bb)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w)
Terre Haute Bronze & Brass Foundry, Ind (bb,cc,dd,ee)
Ullmann, Inc., Wis (o,ee)

Glass, Alumino-Silicate

Corning Glass Works, NY (r,aa,bb,ee)—Ad p 253
L. O. F. Glass Fibers Co., Ohio (s)
Lancaster Glass Corp., Ohio (r)
Russell Mfg. Co., Conn (r,s)

Glass, Borosilicate

Applied Instruments, Inc., NY (z,bb, cc,ee)
Bausch & Lomb Optical Co., NY (r)
Corning Glass Works, NY (r,z,aa,bb,cc,ee)—Ad p 253
Fish-Schurman Corp., NY (bb,ee)
Friedrich & Dimmock, Inc., NJ (r,s)
Gustin-Bacon Mfg. Co., Mo (r,s)
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Marsco Mfg. Co., Ill (r)
Modiglass Fibers, Inc., NJ (s)
Penberthy Instrument Co., Wash (r)
Pittsburgh Corning Corp., Pa (u)
Pittsburgh Plate Glass Co., Fiber Glass Div., Pa (s)—Ad p 209
Russell Mfg. Co., Conn (s)
Semon Bache & Co., NY (z,cc,ee)
Shull Bros. Glass Co., NJ (r,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass, Lead Alkali Silicate

Bausch & Lamb Optical Co., NY (r)
Corning Glass Works, NY (r,aa,bb,ee)—Ad p 253
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Pemberthy Instrument Co., Wash (r,z)
Semon Bache & Co., NY (z,cc,ee)

Glass, 96% Silica

Amersil Quartz Div., Engelhard Industries, Inc., NJ (c,s,z,aa,bb,cc,ee)
Applied Instruments, Inc., NY (z,cc, ee)
Corning Glass Works, NY (r,z,aa,bb,cc,ee)—Ad p 253
L.O.F. Glass Fibers Co., Ohio (s)
Fish-Schurman Corp., NY (bb,ee)
Marsco Mfg. Co., Ill (r)
Russell Mfg. Co., Conn (r,s)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass, Silica

Applied Instruments, Inc., NY (z,cc, ee)
Corning Glass Works, NY (r,z,aa,cc)—Ad p 253
Friedrich & Dimmock, Inc., NJ (r)
L.O.F. Glass Fibers Co., Ohio (s)
Modiglass Fibers, Inc., NJ (s)
Pyrosil, Inc., Ohio (r,z,aa,bb,cc,ee)
Semon Bache & Co., NY (z,cc,ee)

Glass, Soda-Lime

Applied Instruments, Inc., NY (z,bb, cc,ee)
BLC Porous Materials Co., Calif (r,z, cc)
Bausch & Lomb Optical Co., NY (r,s)
Corning Glass Works, NY (r,aa,bb,ee)—Ad p 253
Erie Scientific Corp., NY (cc)
Friedrich & Dimmock, Inc., NJ (r,s, bb,ee)
Lancaster Glass Corp., Ohio (r)
Mansol Ceramics Co., NJ (r,aa)
Modiglass Fibers, Inc., NJ (s)
Semon Bache & Co., NY (z,cc,ee)
Shull Bros. Glass Corp., NJ (r,bb,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)

Glass Coatings

(see Inorganic Coatings)

Glass for Plastics Reinforcement

Bassichis Co., Ohio
Coast Mfg. & Supply Co., Calif
Electrofilm, Inc., Calif
Exeter Mfg. Co., NY
Ferro Corp., Fiber Glass Div., Tenn
Flexfirm Products, Calif
Foss Mfg. Co., Plastics Div., Id
L.O.F. Glass Fibers Co., Ohio
Modiglass Fibers, Inc., NJ
Owens-Corning Fiberglas Corp., Ohio
Pittsburgh Plate Glass Co., Fiber Glass Div., Pa —Ad p 209
Pyrosil, Inc., Ohio
Ren Plastics, Inc., Mich
Rezolin, Inc., Calif
Russell Mfg. Co., Conn
Standard Insulation Co., Plastics Div., NJ
Tallman-McCluskey Fabrics Co., Mo
Thompson, H.I. Fiber Glass Co., Calif
U.S. Polymeric Chemicals, Inc., Conn

Gold and Its Alloys

Advance Stamping Co., Mich (dd)
Alpha Metals, Inc., NJ (t)
American Metal Climax, Inc., NY (w,aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY (n,o,v,z,bb,cc,dd,ee,ff)
American Platinum Works, NJ (z)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (o)
Anaconda Aluminum Co., Sub. of Anaconda Co., NY (o)
Anchor Metal Co., Inc., NY (w)
Baker & Co., Inc., NJ (n,o,v,w,z,bb,cc, dd)
Bart Mfg. Corp., NJ (aa)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (v,cc,dd,ee,ff)
Cerro de Pasco Sales Corp., NY (o)
Deringer Metallurgical Corp., Ill (cc, ee,ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,z,aa,bb,cc,dd,ee,ff)
General Plate Div., Metals & Controls Corp., Mass (n,v,z,bb,cc,dd)
Goldsmith Bros., S. & R. Co., Ill (n,o,v,w,z,aa,bb,cc,dd,ff)
Hagstoz, T.B. & Son, Pa (n,cc,dd,ff)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., NY (aa)
Hastings & Co., Inc., Pa (v)
Hayden Wire Works, Inc., Mass (ff)
Improved Seamless Wire Co., RI (bb, cc,dd,ee,ff)
Lakeland Industries, Minn (z)
Leach & Garner Co., Industrial Div., Mass (n,o,v,z,bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (n,o,v,z,bb,dd, ee,ff)
Metals & Controls Corp., Mass (n,o, q,v,w,z,bb,cc,dd,ee,ff)
Metals Disintegrating Co., Inc., NJ (aa)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (v,z,bb,cc,dd,ee,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Sel-Rex Corp., NJ (n,aa)—Ad p 285
Standard Metals Corp., Mass (n,o,v,z, bb,cc,dd,ee,ff)
Western Gold & Platinum Co., Calif (n,o,aa,bb,cc,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)

Graphite

(see Carbon)

Gray Iron

(see Iron)

GR-S Rubber

(see Styrene-Butadiene Rubber)

Hard Facing Alloys

Air Reduction Sales Co., NY
Alloy Rods Co., Pa
All-State Welding Alloys Co., Inc., NY
American Manganese Steel Div., American Brake Shoe Co., Ill
American Smelting & Refining Co., NY
Arcos Corp., Pa
Champion Rivet Co., Ohio
Cleveland Hard Facing Co., Inc., Ohio
Crucible Steel Co. of America, Pa
Electric Steel Foundry Co., Ore

Fansteel Metallurgical Corp., Ill
General Electric Co., NY
Harnischfeger Corp., Wis
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Hobart Bros. Co., Ohio
Janney Cylinder Co., Pa
Kennametal, Inc., Pa
—Ad p 255
Kinkead Industries, Inc., Ill
Lincoln Electric Co., Ohio
Lincoln Iron Works, Vt
Marquette Mfg. Co., Inc., Minn
McKay Co., Pa
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Metallizing Co. of Los Angeles Inc., Calif
Overmyer Mould Co., Inc., Ind
Republic Steel Corp., Ohio
Reynolds Mfg. Co., Mass
Sommer Metalcraft Corp., Ind
Stevens, Frederic B., Inc., Mich
Stoody Co., Calif
Tiarco Corp., NJ
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
Victor Equipment Co., Calif
Wall Colmonoy Corp., Stainless Process Div., Mich

Hard Surfaces for Metals

(see Diffusion Coatings; Hard Facing Alloys)

High Pressure Laminates

(see Laminates)

Hot Melt Coatings

(see Organic Coatings)

Hypalon

(see Chlorosulfonated Polyethylene Rubber)

Immersion Coatings, Chemical

(Incl. Electroless)

Allied Research Products, Inc., Md
—Ad p 281
Amchem Products, Inc., Pa
Automotive Rubber Co., Inc., Mich
Biddle Screw Products Co., Ind
Birchwood Chemical Co., Minn
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Dollin Corp., NJ
Electro Chemical Engineering & Mfg. Co., Pa
General American Transportation Corp., Ill
Industrial Chromium Corp., Mass
Lithcote Corp., Ill
Magnesium Co. of America, Ind
Marlane Development Co., Inc., NY
Merix Chemical Co., Ill
Metal Finishers, Inc., Md
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Mitchell-Bradford Chemical Co., Conn
Modern Plating Corp., Ill
Octagon Process, Inc., NY
Parker Rust Proof Co., Mich
Promat Div., Poor & Co., Ill
Reynolds Chemical Products Co., Mich
Rustproofing & Metal Finishing Corp., Mass
Stevens, Frederic B., Inc., Mich
Tickle, Arthur Engineering Works, Inc., NY
—Ad p 290
Turco Products, Inc., Calif
WLS Stamping Co., Ohio

Impact Extrusions

(cold extrusions)

Allied Products Corp., Mich (g)
Almco Steel Products Corp., Ind (b,g)
Aluminum Co. of America, Pa (a)—Ad p 331
Bossert Div., Rockwell Spring and Axle Co., NY (g)
Bridgeport Brass Co., Conn (a,b,c,g,h)
Cliff Mfg. Co., Ohio (a,e)
Curtiss-Wright Corp., NY (g)
Cyril Bath Co., Ohio (g)
Dow Chemical Co., Magnesium Div., Mich (e)
Fletcher Enamel Co., W.Va (a,b,c,d,e,f)
Fromson Orban Co., Inc., NY (a)
Harvey Aluminum Div., Harvey Machine Co., Inc., Calif (a)
Heintz Mfg. Co., Pa (g)
Hunter-Douglas Aluminum Div., Bridgeport Brass Co., Calif (a)
Impact Extrusions, Inc., Ind (a)
Impax, Inc., Mo (a,b,e,j)
Ladish Co., Wis (a,b,c,e,f,g,h)
Leake Engineering Co., Mich (a,b,d,g)
Magline, Inc., Mich (e)
Magnesium Co. of America, Ind (a,e)
Mueller Brass Co., Mich (a,b,g)—Ad p 357
Pheoll Mfg. Co., Ill (a,b,c,g)
Presswork, Inc., Mich (d)
Republic Steel Corp., Ohio (g)
Sherman & Reilly, Inc., Tenn (e,f,g)
Sun Tube Corp., NJ (a,b,e)
Thompson Products, Light Metals Div., Ohio (a)
Townsend Co., Pa (a,b,g)
United Shoe Machinery Corp., Mass (a)
Wirz, A.H., Inc., Pa (a,b,d,j)
Worcester Pressed Steel Co., Mass (a)

Impregnated or Compressed Wood

(see Wood)

Impregnation Coatings

(see Organic Coatings)

Indium and Its Alloys

Alpha Metals, Inc., NJ (o,q,t,w,bb,cc,dd)
American Smelting & Refining Co., NY (n,o,q,v,w,bb,cc,dd,ff)
Anaconda Aluminum Co., Sub. of Anaconda Co., NY (aa)
Belmont Smelting & Refining Works, Inc., NY (o)
Cerro de Pasco Sales Corp., NY (o,w)
Division Lead Co., Ill (o,v,cc,ff)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Federated Metals Div., American Smelting and Refining Co., NY (o,q,t,w,bb,cc,dd)
General Plate Div., Metals & Controls Corp., Mass (dd)
Gildden Co., Chemicals-Pigments-Metals Div., Md (aa)
Goldsmith Bros. Smelting & Refining Co., Ill (o,q)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hardy, Charles, Inc. NY (aa)
Indium Corp. of America, NY (n,o,q,v,w,z,aa,bb,cc,dd,ff) — Ad p 133
International Minerals & Metals Corp., NY (w)
Nesor Alloy Products Co., NJ (dd,ff)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Sel-Rex Corp., NJ (aa)
Utica Metals Div., Kelsey-Hayes Co., NY (w)
Western Gold & Platinum Co., Calif (bb,cc,dd)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)

Ingots

(see specific metal)

Injection Moldings

(see Moldings)

Inorganic Coatings, Ceramic

(formulations)

Bisonite Co. Inc., NY
California Metal Enameling Co., Calif
Centralab Div., Globe Union, Inc., Wis
Chicago Vitreous Corp., Div. of Eagle-Picher Co., Ill
Cooley, W.J. & Co., Tenn
Dennis Chemical Co., Mo
Douglas & Sturgess, Calif
France, J.H. Refractories Co., Pa
Harshaw Chemical Co., Ohio
Hayden Wire Works, Inc., Mass
Hitemp Wires, Inc., NY
Hommel, O. Co., Pa
Ingram-Richardson, Inc., Ind
Kraus Research Labs, Md
Laboratory Equipment Corp., Mich
Linde Co., Div. of Union Carbide Corp., NY
Lithium Corp. of America Inc., Minn
Metal & Thermit Corp., NJ
Metallizing Engineering Co., Inc., NY
—Ad pp 128, 278, 290
Norton Co., Mass
—Ad p 288
Philadelphia Enameling Works, Inc., Pa
Refractory & Insulation Corp., NY
Sauereisen Cements Co., Pa
Solar Aircraft Co., Calif
Thermal Refractories Corp., NJ
Zirconium Corp. of America, Ohio

Inorganic Coatings, Ceramic

(coaters)

American Emblem Co., Inc., NY
Bisonite Co., Inc., NY
Brooks & Perkins, Inc., Mich
California Metal Enameling Co., Calif
Centralab Div., Globe Union Inc., Wis
Cooley, W.J. & Co., Tenn
Electrofilm, Inc., Calif
Emerson & Cuming, Inc., Mass
Enamel Products Co., Ohio
Erie Ceramic Arts Co., Pa
Fletcher Enamel Co., W.Va
Hayden Wire Works, Inc., Mass
Ingram-Richardson, Inc., Ind
Lancaster Glass Corp., Ohio
Linde Co., Div. of Union Carbide Corp., NY
Metal-Cladding, Inc., NY
Metallizing Co. of Los Angeles, Inc., Calif
Metaplast Process, Inc., NY
Norton Co., Mass
—Ad p 288
Philadelphia Enameling Works, Inc., Pa
Russell Mfg. Co., Conn
Solar Aircraft Co., Calif
Swedlow Plastics Co., Calif
Thermo Materials, Inc., Calif
Zirconium Corp. of America, Ohio

Inorganic Coatings, Porcelain or Glass

(formulations)

Bettinger Corp., Mass
California Metal Enameling Co., Calif
Chicago Vitreous Corp., Div. of Eagle-Picher Co., Ill
Dennis Chemical Co., Mo

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Du-Co Ceramics Co., Pa
Ferro Corp., Ohio
Harshaw Chemical Co., Ohio
Hitemp Wires, Inc., NY
Hommel, O. Co., Pa
Independence Stove & Mfg. Co., Mo
Ingram-Richardson, Inc., Ind
Lithium Corp. of America Inc., Minn
Metal-Cladding Inc., NY
Pemco Corp., Md
Philadelphia Enameling Works, Inc., Pa
Pierce & Stevens Chemical Corp., NY
Pittsburgh Plate Glass Co., Pa
Sauereisen Cements Co., Pa

Inorganic Coatings, Porcelain or Glass

(enamelers)

American Valve & Enameling Corp., Ind
Applied Instruments, Inc., NY
Barrows Porcelain Enamel Corp., Ohio
Bettinger Corp., Mass
Bevan Co., Calif
California Metal Enameling Co., Calif
Cleveland Porcelain Enameling Co., Ohio
Emerson & Cuming, Inc., Mass
Enamel Products Co., Ohio
Erie Ceramic Arts Co., Pa
—Ad p 282
Erie Enameling Co., Pa
Ervite Co., Pa
Ferro Enameling Co., Calif
Fletcher Enamel Co., W.Va
Frenchtown Porcelain Co., NJ
Geuder, Paeschke & Frey Co., Wis
Heintz Mfg. Co., Pa
Independence Stove & Mfg. Co., Mo
Ingersoll Products Div., Borg-Warner Corp., Ill
Ingram-Richardson, Inc., Ind
Ingram-Richardson Mfg. Co., Pa
Kawneer Co., Mich
Lansdale Porcelain Enamel Corp., Pa
Metal & Thermit Corp., NJ
Metal-Cladding, Inc., NY
Monarch Aluminum Mfg. Co., Ohio
National Metal Products Co., Pa
Penn Fibre & Specialty Co., Inc., Pa
Philadelphia Enameling Works, Inc., Pa
Porcelain Enamel Finishers, Ill
Smith, A.O. Corp., Wis
Smoot-Holman Co., Calif
Southwestern Porcelain Steel Corp., Okla
Temco, Inc., Tenn
Vollrath Co., Wis

Inorganic Fibers

(except Asbestos, Ceramic, Glass, Carbon; see these categories)

Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Baldwin-Hill Co., NJ
Carborundum Co., NY
—Ad p 244
Carey, Philip Mfg. Co., Ohio
Electrofilm Inc., Calif
Gustin-Bacon Mfg. Co., Mo
Johns-Manville Corp., NY
L. O. F. Glass Fibers Co., Ohio
Modiglass Fibers, Inc., NJ
Standard Asbestos Mfg. Co., Ill

Intermetallic Compounds

(see Ceramics; Refractories)

Investment Castings

(see castings)

Iron, Alloy

(castings)

Acme Foundry & Machine Co., Okla
Advance Foundry Co., Ohio
Albion Malleable Iron Co., Mich
Alloy Precision Castings Co., Ohio
Almont Mfg. Co., Mich
Alten Foundry & Machine Works, Inc., Ohio
American Cast Iron Pipe Co., Ala
American Foundries Co., Mich
Apex Foundry, Inc., Mich
Apex Steel Corp., Ltd., Calif
Arzt, T.L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Banner Iron Works, Mo
Barber Iron Work, Inc., La
Bay City Foundry Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Beloit Foundry Co., Ill
Bierman-Everett Foundry Co., NJ
Bignall Co., NY
Blackmer Pump Co., Ohio
Bonnot Co., Ohio
Brom Machine & Foundry Co., Minn
Butler Engine & Foundry Co., Inc., Pa
Cadillac Malleable Iron Co., Mich
Calumet Div., Calumet & Hecla, Inc., Mich
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Casting Service Corp. of Michigan, Mich
Chemung Foundry Corp., NY
Chicago Hardware Foundry Co., Ill
Cleveland Foundry & Mfg. Co., Inc., Tenn
Crawford & Doherty Foundry Co., Ore
Curtiss-Wright Corp., NY
Dalton Foundries, Inc., Ind
Dayton Foundry, Calif
Deuscher, H.P. Co., Ohio
Ehrsam, J.B. & Sons Mfg. Co., Kan
Electric Steel Foundry Co., Ore
Electron Corp., Colo
Elk Engineering Works, Inc., Pa
Enterprise Wheel & Car Corp., Va
Florence Pipe Foundry & Machine Co., NJ
Flynn & Emrich Co., Md
Frederick Iron & Steel, Inc., Md
G. & C. Foundry Co., Ohio
Gale Mfg. Co., Mich
General Electric Co., Foundry Dept., NY
Gillett & Eaton, Inc., Minn
Goslin Birmingham Mfg. Co., Inc., Ala
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Green Bay Foundry & Machine Works, Wis
Greenlee Foundry Co., Ill
Grimm Foundry Co., Inc., NJ
Gunite Foundries Corp., Ill
H & H Foundry Machine Co., Pa
Hamilton Foundry & Machine Co., Ohio
Helmick Foundry-Machine Co., W.Va
Hewitt, John Foundry Co., NJ
Howard Foundry Co., Ill
Irwin Foundry & Mine Car Co., Pa
Janney Cylinder Co., Pa
Keen Foundry Co., Inc., Ind
Kingsport Foundry & Mfg. Corp., Tenn
Kolcast Industries Div., Thompson Products, Inc., Ohio
Kramer Bros. Foundry Co., Ohio
Kutztown Foundry & Machine Corp., Pa
Lake Erie Foundry Co., NY
Lang-Scharmann & Co., Wis
Lawton, C.A. Co., Wis
Liberty Foundry Co., Mo
Lincoln Foundry Corp., Calif
Littlestown Hardware & Foundry Co., Inc., Pa
Lodi Iron Works, Inc., Calif
Long Beach Iron Works, Calif
Macaulay, H.C. Foundry Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Manufacturers Iron Foundry, Inc., Conn
McLanahan & Stone Corp., Pa
Meehanite Metal Corp., NY
Mercast Mfg. Corp., Calif
Metropolitan Iron Foundry, NY
Midwestern Foundries, Inc., Ind
Misco Precision Casting Co., Mich
Montague Machine Co., Mass
National Iron Co., Minn
National Malleable & Steel Castings Co., Ohio
Neenah Foundry Co., Wis
North Wales Foundry Co., Inc., Pa
Oak Hill Foundry & Machine Works, Ohio
Oakland Foundry & Machine Co., Mich
Oil City Iron Works, Tex
Overmyer Mould Co., Inc., Ind
Perkins, Henry Co., Mass
Pittsburgh Foundry & Machine Co., Pa
Pohlman Foundry Co., Inc., NY
Posey Iron Works, Inc., Pa
Potts, C. & G. & Co., Ind
Prescott Co., Mich
Pusey & Jones Corp., Del
Quaker Alloy Casting Co., Pa
Quest, J.F. Foundry Co., Minn
Republic Steel Corp., Ohio
Richmond Foundry & Mfg. Co., Inc., Va
Ridge Foundry, Calif
Riverside Foundry & Galvanizing Co., Mich
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
St. Marys Foundry Co., Ohio
Schaefer-Goodnow Foundries, Inc., Pa
Schneider, Bowman Co., Inc., Pa
Scudder, E.J. Foundry & Machine Co., NJ
Shartle Div., Black-Clawson Co., Ohio
Sheffield Foundry Co., Ill
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sibley Machine & Foundry Corp., Ind
Sioux City Foundry & Boiler Co., Iowa
Sonith Foundries, Food Machinery Corp., Ind
Sorbo-Mat Process Engineers, Mo
—Ad p 355
Sparta Foundry Div., Muskegon Piston Ring Co., Mich
Springfield Foundry Co., Mass
Spuck Iron & Foundry Co., Mo
Star Heel Plate Co., Inc., NJ
Stuart Foundry Co., Mich
Superior Foundry, Inc., Ohio
Taylor & Co., Inc., NY
Taylor & Boggis Foundry, Ohio
Texas Foundries, Inc., Tex
Tower Grove Foundry, Mo
Union Iron Works, Wash
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Uniworld Research Corp. of America, Ohio
Valley Iron Works, Minn
Wall Colmonoy Corp., Stainless Process Div., Mich
Washington Iron Works, Wash
Waterman Industries, Inc., Calif
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga
Zenith Foundry Co., Wis
—Ad p 362

Iron, Gray

(castings)

ACF Industries, Inc., NY
Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Acme Foundry & Machine Co., Okla
Advance Foundry Co., Ohio
Albert Lea Foundry, Div. of Queen Products, Inc., Minn
Allegheny Foundry Co., Pa
Allis-Chalmers Mfg. Co., Wis
Alloy Precision Castings Co., Ohio
Almont Mfg. Co., Mich
Alten Foundry & Machine Works, Inc., Ohio
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Foundries Co., Mich
American Foundry Co., Inc., Ind
American Laundry Machinery Co., NY
Apex Foundry, Inc., Mich
Apex Steel Corp., Ltd., Calif
Appleton Electric Co., Ill
Arneson Foundry Co., Wis
Arzt, T.L. Foundry Co., Ill
Atlantic Foundry Co., Ohio
Atlas Foundry Co., Ohio
Atlas Foundry & Mfg. Co., Calif
Auburn Foundry, Inc., Ind
Avco Mfg. Corp., New Idea Div., NY
Baldwin-Lima-Hamilton Corp., Pa
Banner Iron Works, Mo
Barber Iron Works, Inc., La
Barnett Foundry & Machine Co., NJ
Bay City Foundry Co., Mich
Becker, L.A. Foundry Co., Mo
Bellaire Stove Co., Ohio
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Beloit Foundry Co., Ill
Bethlehem Steel Co., Pa
Bierman-Everett Foundry Co., NJ
Bignall Co., NY
Black-Clawson Co., Ohio
Blackmer Pump Co., Ohio
Bonnot Co., Ohio
Brake Shoe & Castings Div., American Brake Shoe Co., NY
Bruce Foundry and Mfg. Co., Mich
Butler Engine & Foundry Co., Inc., Pa
Calumet Div., Calumet & Hecla, Inc., Mich
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Casting Service Corp. of Michigan, Mich
Chemung Foundry Corp., NY
Chicago Hardware Foundry Co., Ill
Cincinnati Foundry Co., Ohio
Cleveland Foundry & Mfg. Co., Inc., Tenn
Columbiana Pump Co., Ohio
Compton Foundry, Calif
Continental Gin Co., Ala
Cooper-Bessemer Corp., Ohio
Crawford & Doherty Foundry Co., Ore
Dalton Foundries, Inc., Ind
Dayton Malleable Iron Co., Ohio
Decatur Casting Co., Ind
De Laval Steam Turbine Co., NJ
Detroit Brass & Malleable Co., Mich
Deuscher, H.P. Co., Ohio
Dodge Mfg. Co., Ind
Dostal Foundry & Machine Co., Mich
Eaton Mfg. Co., Foundry Div., Mich
Ehrsam, J.B. & Sons Mfg. Co., Kan
Electro Metallurgical Co., Div. of Union Carbide Corp., NY
Electron Corp., Colo
Elk Engineering Works, Inc., Pa
Elkhart Foundry & Machine Co., Inc., Ind
Elkhart Iron Works, Mich
Empire Pattern and Foundry Co., Okla
Enterprise Wheel & Car Corp., Va
Fearon Foundry Co., Ill
Florence Pipe Foundry & Machine Co., NJ
Florin Foundry & Mfg. Co., Pa
Flynn & Emrich Co., Md
Frederick Iron & Steel, Inc., Md
Fulton Foundry & Machine Co., Inc., Ohio
G. & C. Foundry Co., Ohio
Gale Mfg. Co., Mich
Gartland-Haswell Foundry, Inc., Ohio
General Electric Co., Foundry Dept., NY
General Foundry & Mfg. Co., Mich
General Iron Works Co., Colo
General Motors Corp., Central Foundry Div., Mich
Georgia Iron Works, Ga
Gillett & Eaton, Inc., Minn
Glamorgan Pipe & Foundry Co., Va
Goslin-Birmingham Mfg. Co., Inc., Ala

Gowanda Furnaces, Inc., NY
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Green Bay Foundry & Machine Works, Wis
Greenlee Foundry Co., Ill
Grimm Foundry Co., Inc., NJ
Gunite Foundries Corp., Ill
H & H Foundry Machine Co., Pa
Hamilton Foundry & Machine Co., Ohio
Hardinge Mfg. Co., Pa
Headford Bros. & Hitchins Foundry Co., Iowa
Helmick Foundry-Machine Co., W.Va
Hewitt, John Foundry Co., NJ
Hodgson Foundry Co., Ill
Howard Foundry Co., Ill
Independence Stove & Mfg. Co., Mo
International Harvester Co., Ill
International Nickel Co., Inc., NY
Irwin Foundry and Mine Car Co., Industrial and Furnace Car Div., Pa
Janney Cylinder Co., Pa
Johnstone Foundries, Inc., Pa
Kanawha Mfg. Co., W.Va
Kansas City Hay Press Co., Mo
Katelman Foundry & Mfg. Co., Iowa
Keen Foundry Co., Inc., Ind
Kelly Foundry Co., Pa
King-Seeley Corp., Mich
Kingsport Foundry & Mfg. Corp., Tenn
Koehring Co., Wis
Kramer Bros. Foundry Co., Ohio
Kutztown Foundry & Machine Corp., Pa
Lake Erie Foundry Co., NY
Lakeside Malleable Casting Co., Wis
Lang-Scharmann & Co., Wis
Lawton, C.A. Co., Wis
Le Baron, E.L. Foundry, Mass
Lehigh, Inc., Pa
Letukas Foundry, Ind
Lewistown Foundry & Machine Co., Pa
Liberty Foundry Co., Mo
Lincoln Foundry Corp., Calif
Lincoln Iron Works, Vt
Link-Belt Co., Ind
Littite Foundries, Inc., Mich
Littlestown Hardware & Foundry Co., Inc., Pa
Lodge Mfg. Co., Pa
Lodi Iron Works, Inc., Calif
Long Beach Iron Works, Calif
Macaulay, H.C. Foundry Co., Calif
Madison Foundry Co., Ohio
Magirl Foundry & Furnace Co., Ill
Manufacturers Iron Foundry, Inc., Conn
McCarter Iron Works, Inc., Pa
McLanahan & Stone Corp., Pa
Meehanite Metal Corp., NY
Mercast Mfg. Corp., Calif
Metropolitan Iron Foundry, NY
Midwestern Foundries, Inc., Ind
Milwaukee Malleable & Grey Iron Works, Wis
Montague Machine Co., Mass
Morrisville Foundry Co., Inc., Vt
National Grey Iron Foundry, Ill
National Iron Co., Minn
National Malleable & Steel Castings Co., Ohio
National Supply Co., Pa
Neenah Foundry Co., Wis
Noble & Wood Machine Co., NY
North Wales Foundry Co., Inc., Pa
Oak Hill Foundry & Machine Works, Ohio
Oakland Foundry & Machine Co., Mich
Oil City Iron Works, Tex
Overmyer Mould Co., Inc., Ind
Palmyra Foundry Co., Inc., NJ
Pequonnock Foundry, Inc., Conn
Perkins, Henry Co., Mass
Pittsburgh Foundry & Machine Co., Pa
Pohlman Foundry Co., Inc., NY
Posey Iron Works, Inc., Pa
Potts, C. & G. & Co., Ind
Prescott Co., Mich
Pusey & Jones Corp., Del
Quest, J.F. Foundry Co., Minn
Refinery Castings Co., Tex
Republic Steel Corp., Ohio
Richmond Foundry & Mfg. Co., Inc., Va
Ridge Foundry, Calif
Riverside Foundry Co., Pa
Riverside Foundry & Galvanizing Co., Mich
Rodney Hunt Machine Co., Mass
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
St. Marys Foundry Co., Ohio
San Francisco Iron Foundry, Calif
Schaefer-Goodnow Foundries, Inc., Pa
Schneider, Bowman Co., Inc., Pa
Scudder, E.J. Foundry & Machine Co., NJ
Selma Foundry & Machine Co., Ala
Shakopee Foundry Co., Minn
Sharpsville Steel Fabricators, Inc., Pa
Shartle Div., Black-Clawson Co., Ohio
Sheffield Foundry Co., Ill
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sibley Machine & Foundry Corp., Ind
Sioux City Foundry & Boiler Co., Iowa
Sonith Foundries, Food Machinery Corp., Ind
Sorbo-Mat Process Engineers, Mo
—Ad p 355
Southern Car & Mfg. Co., Inc., Ala
Sparta Foundry Div., Muskegon Piston Ring Co., Mich
Spencer's, I.S. Sons, Inc., Conn
Spring City Foundry Co., Pa
Springer's Foundry Co., Inc., Ind
Springfield Foundry Co., Mass
Spuck Iron & Foundry Co., Mo
Star Heel Plate Co., Inc., NJ
Stearns-Roger Mfg. Co., Colo
Sterling Foundry Co., Ill
Sterrit-Thomas Foundry Co., Pa
Stuart Foundry Co., Mich
Superior Foundry, Inc., Ohio
Swayne-Robinson & Co., Ind
Swett, A.L. Iron Works, NY
Taylor & Co., Inc., NY
Taylor & Boggis Foundry, Ohio
Terre Haute Malleable & Mfg. Corp., Ind
Tower Grove Foundry, Mo
Union Iron Works, Wash
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Utica General Jobbing Foundry, Inc., NY
Valley Iron Works, Minn
Vulcan Foundry Co., Calif
Vulcan Rail & Construction Co., NY
Washington Iron Works, Wash
Waterman Industries, Inc., Calif
Werner Foundry & Machine Co., Pa
West Point Foundry & Machine Co., Div. of Batson-Cook Co., Ga
Western Foundry & Machine Works, Inc., Kan
Western Iron & Foundry Co., Inc., Kan
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wollaston Foundry Corp., Mass
Woodruff & Edwards, Inc., Ill
Yale & Towne Mfg. Co., Ill
Zellner Foundry Co., Ohio
Zenith Foundry Co., Wis
—Ad p 362

Iron, Ingot

Alan Wood Steel Co., Pa (o,w)
Armco Steel Corp., Ohio (o,q,z,bb,cc,dd)
Cannon-Muskegon Corp., Mich (w)
Crucible Steel Co. of America, Pa (w)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Foote Mineral Co., Pa (aa)
Globe Steel Abrasive Co., Ohio (aa)
Hayden Wire Works, Inc., Mass (o, bb,ee,ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
National Moldite Co., NY (aa)
National-Standard Co., Mich (ff)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio (w,aa)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (o,ee)
Star Heel Plate Co., Inc., NJ (bb)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)—Ad p 349

Iron, Malleable

(castings)

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Acme Steel & Malleable Iron Works, NY
Albion Malleable Iron Co., Mich
Alloy Precision Castings Co., Ohio
American Chain & Cable Co., Pa
American Malleable Castings Co., Ohio
Appleton Electric Co., Ill
Auto Specialties Mfg. Co., Mich
Badger Malleable & Mfg. Co., Wis
Belcher Malleable Iron Co., Mass
Belle City Malleable Iron, Racine Steel Castings Co., Wis
Cadillac Mallable Iron Co., Mich
Chicago Malleable Castings Co., Ill
Connecticut Malleable Castings Co., Conn
Dayton Malleable Iron Co., Ohio
Detroit Brass & Malleable Co., Mich
Eastern Malleable Iron Co., Del
General Electric Co., Foundry Dept., NY
General Motors Corp., Central Foundry Div., Mich
Hodgson Foundry Co., Ill
Iowa Malleable Iron Co., Iowa
Jamestown Malleable Iron Corp., NY
Laconia Malleable Iron Co., NH
Lake City Malleable Co., Ohio
Lakeside Malleable Castings Co., Wis
Lancaster Malleable Castings Co., Pa
Lehigh, Inc., Pa
Lincoln Foundry Corp., Calif
Link-Belt Co., Ind
McCarter Iron Works, Inc., Pa
Meadville Malleable Iron Co., Pa
Meeker Foundry Co., NJ
Milwaukee Malleable & Grey Iron Works, Wis
Muncie Malleable Foundry Co., Ind
National Malleable & Steel Castings Co., Ohio
Northern Malleable Iron Co., Minn
Prescott Co., Mich
Republic Steel Corp., Ohio
St. Louis Malleable Castings Co., Mo
Sharpsville Steel Fabricators, Inc., Pa
Sorbo-Mat Process Engineers, Mo
Star Heel Plate Co., Inc., NJ
Superior Steel & Malleable Castings Co., Mich
Terre Haute Malleable & Mfg. Corp., Ind
Texas Foundries Inc., Tex
United Shoe Machinery Corp., Mass
U.S. Challenge & Challenge Co., Ill
Vulcan Rail & Construction Co., NY
West Virginia Malleable Iron Co., W.Va
Westmoreland Malleable Iron Co., NY

Iron, Malleable Pearlitic

(castings)

Albion Malleable Iron Co., Mich
Auto Specialties Mfg. Co., Mich
Badger Malleable & Mfg. Co., Wis
Belcher Malleable Iron Co., Mass
Belle City Malleable Iron Co., Wis
Cadillac Mallable Iron Co., Mich
Canton Malleable Iron Co., Ohio
Chain Belt Co., Wis
Dalton Foundries, Inc., Ind
Dayton Malleable Iron Co., G.H.R. Div., Ohio
Eastern Malleable Iron Co., Del
Erie Malleable Iron Co., Pa
Federal Malleable Co., Wis
General Motors Corp., Central Foundry Div., Mich
I-F Mfg. Co., Ohio
Jamestown Malleable Iron Corp., NY
Laconia Malleable Iron Co., NH
Lakeside Malleable Casting Co., Wis
Lehigh Foundries Co., Div. of Lehigh Inc., Pa
Link-Belt Co., Ill
Meadville Malleable Iron Co., Pa
Moline Malleable Iron Co., Ill
National Malleable & Steel Castings Co., Ohio
Northern Malleable Iron Co., Minn
Peoria Malleable Casting Co., Ill
Pratt, William E. Mfg. Co., Ill
St. Louis Malleable Casting Co., Mo
Texas Foundries, Inc., Tex
Wagner Malleable Iron Co., Ill
Webster Mfg., Inc., Ohio

Iron, Nodular or Ductile

(castings)

Acme Foundry & Machine Co., Okla
Advance Foundry Co., Ohio
Alloy Precision Castings Co., Ohio
Alten Foundry & Machine Works Inc., Ohio
American Cast Iron Pipe Co., Ala
Apex Foundry, Inc., Mich
Atlantic Foundry Co., Ohio
Bay City Foundry Co., Mich
Beloit Foundry Co., Ill
Black-Clawson Co., Ohio
Bonnot Co., Ohio
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Chicago Hardware Foundry Co., Ill
Crawford & Doherty Foundry Co., Ore
Curtiss-Wright Corp., Metals Processing Div., NY
Dayton Foundry, Calif
Deuscher, H.P. Co., Ohio
Ehrsam, J.B. & Sons Mfg. Co., Kan
Electron Corp., Colo
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hamilton Foundry & Machine Co., Ohio
Hodgson Foundry Co., Ill
Howard Foundry Co., Ill
International Nickel Co., Inc., NY
Jamestown Malleable Iron Corp., NY
Janney Cylinder Co., Pa
Kutztown Foundry & Machine Corp., Pa
Lincoln Foundry Corp., Calif
Meehanite Metal Corp., NY
Mercast Mfg. Corp., Calif
Montague Machine Co., Mass
Neenah Foundry Co., Wis
Rosedale Foundry & Machine Co., Pa
Ross-Meehan Foundries, Tenn
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio
Sioux City Foundry & Boiler Co., Iowa

Letters in ( ) indicate materials and forms—turn page for key

Southern Car & Mfg. Co., Inc., Ala
United Shoe Machinery Corp., Mass

Iron, Powders

Alan Wood Steel Co., Pa
Alloy Metal Powders, Inc., Iowa
Antara Chemicals Div., General Aniline & Film Corp., NY
Belmont Smelting & Refining Works, Inc., NY
Easton Metal Powder Co., Div. of American Mannex Corp., Pa
Ekstrand & Tholand, NY
Foote Mineral Co., Pa
Hardy, Charles, Inc., NY
Hoeganaes Sponge Iron Corp., NJ
—Ad p 342
Johnson, A. & Co., Inc., NY
Magnetic Powders, Inc., Pa
Metal Hydrides, Inc., Mass
National Moldite Co., NJ
National-U.S. Radiator Corp., Plastic Metals Div., NY
Norwalk Powdered Metals, Inc., Conn
Pyron Corp., NY
—Ad p 338
Republic Steel Corp., Ohio
Sorbo-Mat Process Engineers, Mo
Steel Shot Producers, Inc., Pa
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa

Iron, Wrought

Albert Pipe Supply Co., Inc., NY (ee)
American Silver Co., NY (v,dd)
Antara Chemicals Div., General Aniline & Film Corp., NY (aa)
Byers, A.M., Pa (z)
Cannon-Muskegon Corp., Mich (w)
Dormont Mfg. Co., Pa (ee)
Gary Steel Products Corp., Va (o,z,bb)
Lockhart Iron & Steel Co., Pa (o,q)
National Electric Products Corp., Pa (ee)
Rathbone Corp., Mass (o,bb)
Sharpsville Steel Fabricators, Inc., Pa (z,dd)
Shaw-Kendall Engineering Co., Ohio (ee)
Titanium & Vacuum Metal Products Div., Crucible Steel Co. of America, Pa (o,q,z,bb,cc,dd,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)

Isocyanates

(see Urethanes)

Isoprene - Isobutylene Rubber

Adhesive Products Corp., NY (x)
Armstrong Cork Co., Pa (bb,cc,dd)
Atlas Mineral Products Co., Pa (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb,cc,dd,ee)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (cc)
Electro Chemical Engineering & Mfg. Co., Pa (t,cc)
Enjay Co., Inc., NY
—Ad p 191
Garlock Packing Co., NY
(y,cc)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Chemical Co., Ohio (p,x,y)
Goshen Rubber Co., Inc., Ind
(y)
Hewitt-Robins, Inc., Conn (cc,ee)
Insulation Mfrs. Corp., Ill (bb,cc,dd,ee)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y,cc,dd)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (x,y)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (y,bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x)
Rand Rubber Co., NY (t,cc)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,ee)
Rogers Corp., Conn (cc,dd)
Roth Rubber Co., Ill (y,cc)
Sheller Mfg. Corp., Mich (u)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (y,cc,dd)
Technical Specialties Co., NY (dd)
Thiokol Chemical Corp., NJ (p)
U.S. Rubber Co., Kem-Blow Dept., Conn
(u)—Ad p 216
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill
(y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y,bb,cc,dd,ee)

Lacquers

(see Organic Coatings)

Laminates

(see below; also Pre-Impregnated Materials)

Laminates, High Pressure, Plastics or Rubber

(sheet, rod or tube; incl. clad laminates)

Acme Specialties, Inc., Pa (k,l,m)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Brakeblok Div., American Brake Shoe Co., Mich (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ
(k,l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Auburn Plastic Engineering, Ill (k)
Baer, N.S. Co., NJ (l)
Cadillac Plastic & Chemical Co., Mich (l)
Calfibe Co., Inc., Calif (l)
Capac Industries, Inc., Mich (l)
Castle Rubber Co., Pa (m)
Coating Products, Inc., NJ
(l)—Ad p 291
Colonial Art Co., Inc., Mass (k)
Conneaut Rubber and Plastics Co., Ohio (k,l,m)
Connecticut Hard Rubber Co., Conn (m)
Conolite Div., Continental Can Co., Del (l)
Consoweld Corp., Wis (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Davidson Rubber Co., Mass (m)
Davis, Joseph Plastics Co., NJ (k)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (m)
Dumont Corp., Calif (k,l,m)
du Pont de Nemours, E.I. & Co., Inc., Del (l)
Electro Chemical Engineering & Mfg. Co., Pa (k,m)
Everlite Corp., Wash (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Farley & Loetscher Mfg. Co., Iowa (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Gatke Corp., Ill (l)
General Electric Co., Laminated Products Dept., Ohio (l)
General Plastics Corp., Ind (k)
General Tire & Rubber Co., Ind (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
H & R Industries, Pa (k)
Hartwell, H.N. & Son, Inc., Mass (k)
Haskelite Mfg. Corp., Mich (l)
Haveg Industries, Inc., Del (l)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Iten Fibre Co., Ohio (l)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (k)
Kerr, R.W. Plastic Co., Neb (k,l)
Lewis, J.P. Co., Plastic Products Div., NY (l)
Luminous Resins, Inc., Ill (k)
Maloney, F.H. Co., Tex (l)
Marblette Corp., NY (l)
Mechanical Rubber Products Co., NY (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Mico Corp., Calif (l)
National Vulcanized Fibre Co., Del
(l)
New England Laminates Co., Inc., Conn
(l)—Ad p 220
Northern Plastics Corp., Wis (l)
Panelyte Div., St. Regis Paper Co., NY (l)
Penn Fibre & Specialty Co., Inc., Pa (l)
Philrus Products Co., NJ (k,l)
Porter, William Co., Calif (l)
Prince Rubber Co., Inc., NY (k)
Quaker Rubber Div., H.K. Porter Co., Pa (k,m)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastics, Inc., Mich (l)
Replac Corp., Ohio (k,l,m)
Richardson Co., NY (l)
Rogers Corp., Conn (l)
Ryerson, Joseph T. & Son, Inc., Ill (l)
Seiberling Rubber Co., Plastics Div., Ohio (k,m)
Shamban, W.S. & Co., Ind (k)
Spaulding Fibre Co., Inc., NY
(l)
Standard Insulation Co., NJ (l)
Sun Steel Co., Ill (k)
Swedlow Plastics Co., Calif (k,l)
Synthane Corp., Pa
(l)
Taylor Fibre Co., Pa
(l)
Thombert, Inc., Iowa (l)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k)
U.S. Polymeric Chemicals, Inc., Conn (k)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (m)
Vulcanized Rubber & Plastics Co., Pa (m)
Westlake Plastics Co., Pa (l)

Laminates, Low Pressure, Plastics or Rubber

(sheet, rod or tube; incl. clad laminates)

Acme Specialties, Inc., Pa (k,l,m)
Allegheny Plastics, Inc., Pa (k)
Allied Resinous Products, Inc., Ohio (k)
Alsynite Co. of America, Calif (l)
American Agile Corp., Ohio (k)
American Insulator Corp., Pa
(l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (m)
Auburn Plastic Engineering, Ill (l)
Baer, N.S. Co., NJ (l)
Biggs, Carl H. Co., Inc., Calif (l)
Blank, Arthur & Co., Inc., Mass (k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (l)
Capac Industries, Inc., Mich (l)
Carroll, J.B. Co., Ill (k)
Castle Rubber Co., Pa (m)
Clad-Rex Corp., Ill (k)
Coating Products, Inc., NJ
(l)—Ad p 291
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa
(l)
Continental Can Co., NY (l)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Corite Products Inc., Ill (l)
Corrulux Div., L.O.F. Glass Fibers Co., Tex (l)
Dumont Corp., Calif (k,l,m)
du Pont de Nemours, E.I. & Co., Inc., Del (l)
Dura Plastics of New York, Inc., NY (k)
Eljay Corp., Md (k,l)
Emerson & Cuming, Inc., Mass (k,l,m)
Everlite Corp., Wash (l)
Fiber Glass Industries, Inc., NY (l)
Filon Plastics Corp., Calif (l)
Foss Mfg. Co., Plastics Div., Id (l)
Frost Rubber Co., Ill (m)
Fry Plastics Co., Calif (k)
General American Transportation Corp., Ill (l)
Gering Products, Inc., NJ (k)
Glastic Corp., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Haskelite Mfg. Corp., Mich (l)
Haveg Industries, Inc., Del (l)
Hays Mfg. Co., Pa (l)
Heil Process Equipment Corp., Ohio (l)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Kaykor Industries, Inc., NJ (k)
Kerr, R.W. Plastic Co., Neb (k,l)
Koch, H. & Sons, Calif (l)
Laminated Plas-Tex Corp., Ohio (k)
Lamtex Industries, Inc., NY (m)
Lun Laminates, Inc., NY (l)
Mechanical Rubber Products Co., NY (l)
Mica Insulator Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Mico Corp., Calif (l)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div,. Minn
(l)—Ad pp 206-207
Molded Fiber Glass Sheet Co., Ohio
(l)
National Vulcanized Fiber Co., Del
(l)
New England Laminates Co., Inc., Conn.
(l)—Ad p 220

Penn Fibre & Specialty Co., Inc., Pa (l)
Perry Plastics Inc., Pa (k,l)
Philrus Products Co., NJ (k,l)
Porter, William Co., Calif (l)
Precision Paper Tube Co., Ill (l)
Prince Rubber Co., Inc., NY (k,m)
Rand Rubber Co., NY (k,l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastic, Inc., Mich (l)
Replac Corp., Ohio (l,m)
Resolite Corp., Pa (l)
Rowland Products, Inc., Conn (k)
Rubatex Div., Great American Industries, Inc., Va (u)
Rubber Corp. of America, NY (k)
Russell Reinforced Plastics Corp., NY (l)
Schori Process Div., Ferro-Co Corp., NY (l)
Scranton Plastic Laminating Corp., Pa (k)
Sealview Plastics, Inc., Pa (l)
Sewell Mfg. Co., Mich (k)
Shamban, W.S. & Co., Ind (k)
Southern Plastics Co., SC (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Standard Insulation Co., NJ (l)
Stockwell Rubber Co., Inc., Pa (k,m)
Stone Paper Tube Co., Washington, DC (k)
Strick Plastics Co., Pa (m,k,l)
Swedlow Plastics Co., Calif (k,l)
U.S. Polymeric Chemicals, Inc., Conn (k)
U.S. Rubber Co., NY (k)
Urrite Plastics Fabricators, Calif (k)
Vulcan Rubber Products Div., Reeves Bros. Inc., NY (m)
Vulcanized Rubber & Plastics Co., Pa (m)
Westlake Plastics Co., Pa (l)
Woodall Industries, Inc., Mich (k,l)
Youngstown Sheet & Tube Co., Ohio (l)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (l)

Laminates, High or Low Pressure, Plastics or Rubber—Moldings

(incl. clad laminates)

Admiral Corp., Molded Products Div., Ill (l)
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Brakeblok Div., American Brake Shoe Co., Mich (k)
American Insulator Corp., Pa (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Arrowhead Products, Calif (l,m)
Artmor Plastics Corp., Md (l)
Baer, N.S. Co., NJ (l)
Bassons Industries, Corp., NY (l)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (l)
Camfield Fiberglass Plastics, Inc., Mich (l)
Carroll, J.B. Co., Ill (k)
Castle Rubber Co., Pa (m)
Chemical Products Corp., RI (k)
Colonial Art Co., Inc., Mass (k)
Colonial Rubber Co., Ohio (k,m)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Corite Products, Inc., Ill (l)
Dumont Corp., Calif (k,l,m)
Eljay Corp., Md (l)
Englander Co., Inc., Industrial Products Div., Md (l)
Fiber Glass Industries, Inc., NY (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foss Mfg. Co., Plastics Div., Id (l)
Frost Rubber Co., Ill (m)
Fry Plastics Co., Calif (l)
Galigher Co., Utah (k)
Gatke Corp., Ill (l)
General American Transportation Corp., Ill (l)
General Electric Co., Laminated & Insulating Products Dept., Ohio (l)
General Tire & Rubber Co., Ind (k)
Gering Products, Inc., NJ (k)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio (l)
H & R Industries, Pa (k)
Haskelite Mfg. Corp., Mich (l)
Haveg Industries, Inc., Del (l)
Hays Mfg. Co., Pa (l)
Hewitt Rubber Div., Hewitt-Robins, Inc., NY (m)
Home Rubber Co., NJ (m)
Insulation Mfrs. Corp., Ill (k)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (k)
Kerr, R.W. Plastic Co., Neb (k,l)
Knight, Maurice A., Ohio (l)
Lamtex Industries, Inc., NY (k,l)
Lone Star Plastics Co., Inc., Tex (l)
Lunn Laminates, Inc., NY (k,l)
Maloney, F.H. Co., Tex (l)
Marblette Corp., NY (l)
Mechanical Rubber Products Co., NY (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Reinforced Plastics Div,. Minn
(l)—Ad pp 206-207
Molded Fiber Glass Co., Ohio
(l)—Ad p 364
National Vulcanized Fiber Co., Del
(l)—Ad p 225
New England Laminates Co., Inc., Conn
(l)—Ad p 220
Northwest Plastics Industries, Inc., Minn (l)
Panelyte Div., St. Regis Paper Co., NY (l)
Penn Fibre & Specialty Co., Inc., Pa (k)
Plymouth Industrial Products, Inc., Wis (k)
Porter, William Co., Calif (l)
Quaker Rubber Div., H.K. Porter Co., Pa (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Ren Plastic, Inc., Mich (l)
Replac Corp., Ohio (k,l,m)
Resolite Corp., Pa (l)
Richardson Co., Ill (l)
Riverside Plastics Corp., NY (l)
Russell Reinforced Plastics Corp., NY (l)
Shamban, W.S. & Co., Ind (k)
Sierra Electric Corp., Calif (k,l)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Spaulding Fibre Co., Inc., NY
(l)—Ad p 217
Standard Insulation Co., NJ (l)
Stockwell Rubber Co., Inc., Pa (k,m)
Strick Plastics Co., Pa (k,l,m)
Sun Rubber Co., Ohio (m)
Swedlow Plastics Corp., Calif (k,l)
Synthane Corp., Pa
(l)—Ad p 200
Taylor Fibre Co., Pa
(l)—Ad p 194
Thompson, H.I. Fiber Glass Co., Calif (k)
Toledo Industrial Rubber Co., (l)
U.S. Polymeric Chemicals, Inc., Conn (k)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (m)
Waterbury Cos., Inc., Conn (l)
Winner Mfg. Co., Inc., NJ (l)
Wittman, Lawrence & Co., NY (l)
Woodall Industries, Inc., Mich (k,l)
Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (l)

Laminates, Metal-Metal

(incl. "bimetals"; key letters refer to base metal)

Al-Fin Div., Fairchild Engine & Airplane Corp., NY (a,e)
Almco Steel Products Corp., Ind (g)
American Cast Iron Pipe Co., Ala (c,g)
American Silver Co., Inc., NY (b,c,f,g)
Baker & Co., Inc., NJ (b,f)
Bridgeport Brass Co., Conn (b,g)
Chace, W.M. Co., Mich (a,b,c,e,f,g,h,j)
Copperweld Steel Co., Ohio (g)
Eastern Brass & Copper Co., NY (a)
Eastern Smelting & Refining Corp., Mass (b)
Gar Precision Parts, Inc., Conn (b,f)
General Finding & Supply Co., Industrial Div., Mass (b,f)
General Plate Div., Metals & Controls Corp., Mass (a,b,c,e,f,g,h,j)
Improved Seamless Wire Co., RI (b, c,f)
Knapp Mills, Inc., NY (b,g)
Laminated Shim Co., Conn (a,b,g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b,c,f,g)
Mechanical Steel Tubing Corp., NY (a,g)
Revere Copper & Brass, Inc., Foil Div., NY (a)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Standard Metals Corp., Mass (a,b,c,f, g)
Staver Co., Inc., NY (a,b)
Sylvania Electric Products, Inc., NY (b,f)
Wilson, H.A. Co., NJ (b,f,g)
Wisconsin Gasket & Mfg. Co., Ohio (b,g)

Laminates, Metal-Organic

(key letters refer to base metal)

American Nickeloid Co., Ill (a,g)
Arvin Industries, Inc., Ind (a,e,g)
Benjamin Electric Mfg. Co., Ill (g)
Clad-Rex Corp., Colo (a,g)
Coated Coil Corp., NY (a,g)
Cochran Foil Co., Ky (a)
Dumont Corp., Calif (a)
Enamel Products Co., Ohio (a,c)
Enamelstrip Corp., Sub. of National Steel Corp., Pa (a,b,c,f,g,j)
Gomar Mfg. Co., Inc., NJ (a)
Hood Rubber Co., Div. of B.F. Goodrich Chemical Co., Mass (a,g)
Kaiser Aluminum & Chemical Sales Inc., Ill (a)
Maloney, F.H. Co., Tex (g)
Mechanical Steel Tubing Corp., NY (a,g)
Met-L-Wood Corp., Ill (a,b,d,f,g)
O'Sullivan Rubber Corp., Va (a,b,e,g)
Sun Steel Co., Ill (a,g)
U.S. Steel Corp., Irvin Works, Pa (g)
Young, M.M. Div., Litho-Strip Corp., Ill (a,g)

Laminates, Wood-Metal

Haskelite Mfg. Corp., Mich
Keller Products, Inc., NH
Laminated Veneers Co., NY
Met-L-Wood Corp., Ill
U.S. Plywood Corp., NY

Laminating Resins

(see specific plastic or rubber)

Lead and Its Alloys

A & A Die Casting Co., Calif (q)
Advance Stamping Co., Mich (dd)
Alpha Metals, Inc., NJ (n,o,v,w,z,aa, bb,cc,dd)
American Metal Climax, Inc., NY (n,o,w,aa,bb)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

American Nickel Alloy Mfg. Corp., NY (w)
American Sheet Metal Works, Inc., Conn (cc)
American Smelting & Refining Co., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Bar-Ray Products, NY (v,z,cc)
Bearium Metals Corp., NY (w)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,z,aa,cc,ff)—Ad p 130
Bunker Hill Co., Calif (n,o,w,z,bb,cc,dd,ee,ff)
Cerro de Pasco Sales Corp., NY (w)
Chicago Smelting & Refining Corp., Ill (w)
Crown Metal Co., Wis (n,o,q,w,bb,cc,dd,ee,ff)
Designers Metal Corp., Ill (cc)
Dietzel Lead Burning Co., Pa (n,o,z,cc)
Division Lead Co., Ill (n,o,v,w,z,cc,dd,ee,ff)
Dixie Lead Co., Tex (n,o,q,w,aa,cc)
Eagle-Picher Co., Ohio (aa)
Empire Metal Co., NY (n,o,q,v,w,z,bb,cc,dd,ee,ff)
Evans Metal Co., Ga (w,cc,ee)
Fox Products Co., Pa (n)
General Plate Div., Metals & Controls Corp., Mass (dd)
Glidden Co., Chemicals-Pigments-Metals Div., Md (aa)—Ad p 347
Goldsmith Bros. Smelting & Refining Co., Ill (o,q,w)
Greenback Industries, Inc., Mich (aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hayman, Michael & Co., NY (o,w)
Heil Process Equipment Corp., Ohio (n)
Hi-Grade Alloy Corp., Ill (n,o,v,w,z,bb,cc,ee,ff)
Hudson Smelting & Refining Co., NJ (w)
Indium Corp. of America, NY (v,cc,dd,ff)
Johnston Foil Mfg. Co., Mo (v,cc)
Kinkead Industries, Inc., Ill (cc,dd)
Kirk, Morris P. & Son, Calif (n,o,q,w,z,aa,bb,cc,dd)
Lavin, R. & Sons, Inc., Ill (n,w)
McGean Chemical Co., Ohio (n,o,bb,dd)
Metal & Thermit Corp., NJ (n)
Metallizing Co. of Los Angeles, Inc., (ff)
Metals Disintegrating Co., Inc., NJ (aa)
National Lead Co., NY (n,o,q,w,z,aa,bb,cc,dd,ee,ff)
National Lead Construction Co., Inc., NJ (n,o,w,z,cc,ee,ff)
Nesor Alloy Products Co., NJ (ff)
New England Smelting Works, Inc., Mass (o,w)
Oatey, L.R. Co., Ohio (o,w,cc,dd)
Olds Alloy Co., Calif (q,w)
Peerless Alloy Co., Colo (n,o,q,w,z,bb,cc)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Pittsburgh Smelting & Refining Co., Pa (o,w,cc)
Republic Lead Equipment Co., Ohio (n)
Republic Metals Co., Inc., NY (n,o,q,v,w,z,cc,ee,ff)
Revere Copper & Brass, Inc., Foil Div., NY (v)
River Smelting & Refining Co., Ohio (o,w)
Rotometals, Calif (o,w,bb,cc,dd,ee,ff)
St. Joseph Lead Co., NY (w)
Sail, George Metals Co., Inc., Pa (w)
Staver Co., Inc., NY (v,cc,dd)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)
U.S. Smelting, Refining & Mining Co., NY (w)
U.S. Stoneware Co., Ohio (n)
Waltham Foundry Co., Mass (w)

Leather and Leather Parts

Alexander Bros. Belting Co., NJ
Alexander, E.P. & Son, Pa
Auburn Mfg. Co., Conn
Bond, Charles Co., Pa
Charlotte Leather Belting Co., NC
Chicago Rawhide Mfg. Co., Ill —Ad pp 187-88
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill
Donovan, F.C., Inc., Mass
Excelsior Leather Washer Mfg. Co., Inc., Ill
Foss Mfg. Co., Plastics Div., Id
Garlock Packing Co., NY
General Gasket, Inc., Conn
Gibb, Walton Leather Co., Pa
Glenn, Joseph & Sons, Inc., Pa
Graton & Knight Co., Inc., Mass
Haffner Bros. Co., Ohio
Hay, James E. Leather Co., Mass
Houghton, E.F. & Co., Pa
International Packings Corp., NH
Mechanical Leathers, Inc., Pa
Michigan Leather Products Co., Mich
National Gasket & Washer Mfg. Co., Inc., NY
Norwich Leather Co., Conn
Page Belting Co., NH
Penn Fibre & Specialty Co., Inc., Pa
Porter, William Co., Calif
Rees' Sons, Hans, NY
Rhoads, J.E. & Sons, Del
Schachner Leather & Belting Co., NC
Shingle Leather Co., NJ
Southern Belting & Transmission Co., Ga
Special Leathers Co., Pa
Standard Washer & Mat, Inc., Conn
Staver Co., Inc., NY
Truche Leather Co., Mass
Warren Belting Co., Mass
Winworth Co., Inc., NJ

Lignum Vitae

(see Wood)

Lithium

American Potash & Chemical Corp., Calif (w)
Belmont Smelting & Refining Works, Inc., NY (o,aa)
Foote Mineral Co., Pa (w)
Hardy, Charles, Inc., NY (aa)
Lithium Corp. of America, Inc., Minn (w,bb,ff)—Ad p 124

Low Pressure Laminates

(see Laminates)

Magnesium and Its Alloys

Aluminium Ltd. Sales, Inc., NY (w)
Aluminum Co. of America, Pa (n,o,q,z,bb,cc,dd)
Aluminum & Magnesium, Inc., Ohio (w)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,w)
Apex Smelting Co., Ill (n,w)
Armet Alloys, Inc., Ohio (n,w)
Belmont Smelting & Refining Works, Inc., NY (w)—Ad p 130
Brooks & Perkins, Inc., Mich (z,cc,dd)—Ad p 362
Copper & Brass Sales, Inc., Mich (o,z,bb,cc,dd,ee,ff)
Dahlin, C.A. Co., Ill (cc)
Designers Metal Corp., Ill (cc)
Dow Chemical Co., Magnesium Div., Mich (n,o,q,w,z,aa,bb,cc,dd,ee,ff)
Hardy, Charles, Inc., NY (aa)
King Laboratories, Inc., NY (w,aa)
Kinkead Industries, Inc., Ill (cc,dd)
Light Metals, Inc., Ind (n)
Magline, Inc., Mich (o,z,bb,cc,ee,ff)
Magna Mfg. Co., Inc., NJ (aa)
Magnesium Elektron, Inc., NY (n,w)
Magnode Products, Inc., Ohio (n,o,bb,dd,ee)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,ee)
McGean Chemical Co., Ohio (aa)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Norrich Plastics Corp., NY (o,bb)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Reade Mfg. Co., Inc., NJ (aa)
Standard Magnesium Corp., Okla (n,q,w)
Tube Distributors Co., Inc., NY (ee)
Ullmann, Inc., Wis (o,ee)
U.S. Magnesium Co., NY (aa)
Utical General Jobbing Foundry, Inc., NY (o)
Waltham Foundry Co., Mass (w)
White Metal Rolling & Stamping Co., NY (n,o,q,z,bb,cc,dd,ee,ff)

Manganese and Its Alloys

Amalgamated Steel Corp., Ohio (o,bb)
American Nickel Alloy Mfg. Corp., NY (w)
Belmont Smelting & Refining Works, Inc., NY (w,aa)
Chicago Development Corp., Md (o,v,z,bb,cc,dd,ee,ff)
Dahlin, C.A. Co., Ill (cc)
Electro Metallurgical Co., Div. of Union Carbide Corp., NY (aa)
Foote Mineral Co., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Hommel, O. Co., Pa (aa)
Lavin, R. & Sons, Inc., Ill (w)
McGean Chemical Co., Ohio (aa)
Metals Disintegrating Co., Inc., NJ (aa)
National Paint & Manganese Co., Va (aa)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
New Jersey Zinc Co., NY (w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Pioneer Aluminum, Inc., Calif (z)
Reade Mfg. Co., Inc., NJ (aa)
Tube Distributors Co., Inc., NY (ee)
Utica General Jobbing Foundry, Inc., NY (aa)
Vanadium Corp. of America, NY (w)

Manganese Bronze

(see Copper)

Mechanical Fasteners

Abalon Precision Mfg. Corp., NY
Acme Machine Products Div., Serrick Corp., Ind
Acme Stamping & Mfg. Co., Pa
Albany Products Co., Inc., Conn
Allmetal Screw Products Co., Inc., NY
American Screw Co., Conn
American Sheet Metal Works, Inc., Conn
Anti-Corrosive Metal Products Co., Inc., NY
Atlantic Steel Co., Ga
Automatic Nut Co., Pa
Automotive Rubber Co., Inc., Mich
Aviation Developments, Inc., Calif
Boots Aircraft Nut Corp., Conn
Buffalo Bolt Div., Buffalo-Eclipse Corp., NY
C. E. M. Co., Conn
Camloc Fastener Corp., NJ
Central Screw Co., Ill
Champion Rivet Co., Ohio —Ad p 398
Chicago Rivet & Machine Co., Ill
Chicago Screw Co., Div. of Standard Screw Co., Ill
Cleveland Cap Screw Co., Ohio
Consolidated Fruit Jar Co., NJ
Continental Screw Co., Mass
Dimco-Gray Co., Ohio
Driv-Lok Sales Corp., Ill
Elastic Stop Nut Corp. of America, NJ
Electric Steel Foundry Co., Ore
Erie Bolt & Nut Co., Pa
Falstrom Co., NJ
Gries Reproducer Corp., NY —Ad pp 338, 402
Grip Nut Co., Ind
Groov-Pin Corp., NJ
Hartford Machine Screw Co., Div. of Standard Screw Co., Conn
Hassall, John, Inc., NY —Ad p 401
Heli-Coil Corp., Conn
Hi-Shear Rivet Tool Co., Calif
Huck Mfg. Co., Mich
Ideal Can Co., Mass
Jaques Co., Mass
Kinkead Industries, Inc., Ill
Klincher Locknut Corp., Ind
Langsenkamp, F.H. Co., Ind
Lincoln Iron Works, Vt
Lundquist Tool & Mfg. Co., Inc., Mass
Magnesium Co. of America, Ind
Magnesium Products of Milwaukee, Inc., Wis
Metal Goods Corp., Mo
National Lock Co., Fastener Div., Ill
National Machine Products Co., Mich
Nelson Stud Welding Div., Gregory Industries, Inc., Ohio
Nutt-Shel Co., Calif
Ohio Nut & Bolt Co., Ohio
Palnut Co., NJ
Parker-Kalon Div., General American Transportation Corp., NJ
Plastiglide Mfg. Corp., Calif
Red Devil Mfg. Co., Ill
Reynolds Aluminum Supply Co., Ga
Rhode Island Tool Co., RI
Rolled Alloys, Inc., Mich
Rotor Clip Co., NY
Russell, Burdsall & Ward Bolt & Nut Co., NY
Set Screw & Mfg. Co., Ill
Shakeproof Div., Illinois Tool Works, Ill
Shur-Lok Corp., Calif
Simmons Fastener Corp., NY —Ad pp 396-7
Simonsen Metal Products Co., Ill
Snyder Mfg. Co., Inc., Ohio
Southco Div., South Chester Corp., Pa
Southern Screw Co., NC
Standard Locknut & Lockwasher, Inc., Ind
Standard Pressed Steel Co., Pa
Star Expansion Industries Corp., NY
Thompson-Bremer & Co., Ill
Thomson, Judson L. Mfg. Co., Mass
Tinnerman Products, Inc., Ohio
Torrington Co., Conn
Townsend Co., Pa
United Shoe Machinery Corp., Mass
United-Carr Fastener Corp., Mass
Waldes Kohinoor, Inc., NY
Waterbury Pressed Metal Co., Conn
Waterman Industries, Inc., Calif
Weckesser Co., Ill
Wesbar Stamping Corp., Wis
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio
Whitehead Metal Products Co., Inc., NY
Worth Co., Wis

Melamines

Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (y)
American Cyanamid Co., Plastics & Resins Div., NY (p,x,y)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Catalin Corp. of America, NY (p,x)
Colonial Kolonite Co., Ill (bb,cc,ee)
Consoweld Corp., Wis (cc)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Dapol Plastics, Inc., Mass (y)
Farley & Loetscher Mfg. Co., Plastics Div., Iowa (cc)
Fiberite Corp., Minn (y)
Formica Corp., Sub. of American Cyanamid Co., Ohio (bb,cc,ee)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)
Haskelite Mfg. Corp., Mich (cc,dd)
Iten Fibre Co., Ohio (bb,cc,dd,ee)
Kurz Kasch, Inc., Ohio (y)
Laminated Plastex Corp., Ohio (x,cc)
Loven Chemical of California, Calif (p,y)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Monsanto Chemical Co., Plastics Div., Mass (p,x,y)
Muehlstein, H. & Co., Inc., NY (p,y)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
Northern Plastics Corp., Wis (cc,dd)
Omni Products Corp., NY (y)
Panelyte Div., St. Regis Paper Co., NY (x,bb,cc,dd,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Reichhold Chemical, Inc., NY (p,x)
Richardson Co., NY (bb,cc,ee)
Robot Devices, Inc., Va (u)
Spaulding Fibre Co., Inc., NY (bb,cc,dd,ee)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Texas Glass Fiber Corp., Tex (y)
U.S. Polymeric Chemical, Inc., Conn (s)
Westlake Plastics Co., Pa (bb,cc,dd,ee)

Metal Powder Parts

(Metal Compacts)

Allied Products Corp., Mich (c)
Aluminum Co. of America, Pa (a)
American Brake Shoe Co., NY (a,b,c,f,g,)
American Nickel Alloy Mfg. Corp., NY (f)
American Powdered Metals, Inc., Conn (b,c,f)
American Sinteel Corp., NY (b,c,d,g)
American Sinterings Div., Engineered Plastics, Inc., Conn (b,c,f,g,j)
Amplex Div., Chrysler Corp., Mich (b,c,f,g)
Arnold Engineering Co., Ill (c,f)
Arrow Sintered Products Co., Ill (b,c,g)
Asco Sintering Corp., Calif (a,b,c,d,f,g)
Atlas Brass Foundry, Calif (b,c)
Bassick Co., Conn (a,b,c,f,g)
Bendix Aviation Corp., NJ (a,b,c,f,g)
Boston Gear Works, Mass (a,b,c,f,g)
Bound Brook Oil-Less Bearing Co., NJ (b,c,f)
Brockway Pressed Metals, Inc., Pa (a,b,c,f,g)
Bunting Brass & Bronze Co., Ohio (b,c)
Burgess-Norton Mfg. Co., Ill (a,b,c,f,g)
Ceromet, Inc., Calif (b,c,f,g)
Chicago Powdered Metals Products Co., Ill (a,b,c,f,g)
Cleveland Graphite Bronze Co., Ohio (a,b,c,f,g)
Compacted Metals Corp., Ill (b,c)
Diamond Mfg. Co., Pa (a,b,f,g)
Dixon Sintaloy, Inc., Conn (b,c,f,g,h,j)
Eaton Mfg. Co., Powdered Metals Div., Mich (b,c,d,f,g,j)
Eberhart Steel Products, Powdered Metals Div., Ind (b,c)
Engineered Plastics & American Sinterings, Inc., Conn (b,c,f,g)
Ferro Powdered Metals, Ind (b,c,f,g)
General Metals Powder Co., Ohio (b,c,d,j)
General Motors Corp., Moraine Products Div., Ohio (a,b,c,f,g)
General Powdered Metal Products, Inc., Holly Corp., Conn (a,b,c,f,g)
General Sintering Corp., Ill (a,b,c,f,g)
Gibson Electric Co., Pa (a,b,c,f)
Haller, Inc., Mich (b,c,g)
Indar Corp., Ind (a,b,c,f,g)
Indiana Steel Products Co., Ind (a,b,c,f,g)
International Powder Metallurgy Co., Inc., Pa (a,b,c,d,f,g,j)
Jet Components, Inc., Calif (b,c)
Johnson Bronze, Pa (b,c)
Keystone Carbon Co., Pa (a,b,c,f,g,h)
Kwikset Powdered Metal Products, Calif (b,c,d,f,g)
Lux Clock Mfg. Co., Inc., Conn (a,b,c,f,g)
Magnetic Core Corp., NY (c)
Mallory, P.R. & Co., Inc., Ind (g)
Merriman Bros., Inc., Mass (b,c,f,g)
Michigan Powdered Metal Products Co., Mich (a,b,c,f,g)
Micro Metallic Corp., NY (a,b,c,f,g)
Micro-Metals Co., Calif (a,b,c,e,f)
Midwest Sintered Products Corp., Ill (b,c)
Mueller Brass Co., Mich (a,b,c,f,g)—Ad p 357
National Molded Products, Inc., Pa (a,b,c,f,g)
National Moldite Co., NJ (c)
Norwalk Powdered Metals, Inc., Conn (b,c,f,g,j)
Pacific Sintered Metals Co., Calif (b,c)
Parker White Metal Co., Pa (b,c,f,g)
Picco, Inc., Calif (c)
Powder Metals Products Co., Pa (a,b,c,f,g)
Powdercraft Corp., SC (a,b,c,f,g)
Precision Metal Products Co., Pa (b,c)
Presmet Corp., Mass (b,c,f,g,j)
Pure Carbon Co., Inc., Pa (c)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (a,b,c,e,f)
Reese Metal Products Corp., Pa (b,c,g)
Republic Steel Corp., Ohio (c)
Russell Mfg. Co., Conn (b)
St. Marys Carbon Co., Pa (b,c,f)
Schwarzkopf Development Corp., NY (a,b,c,e,f)
Sintercast Corp. of America, NY (a,b,c,f,g)
Sintered Metals, Inc., Mass (b,c)
Sparta Foundry Div., Muskegon Piston Ring Co., Mich (c)
Star Heel Plate Co., Inc., NJ (c)
Superior Carbon Products, Inc., Ohio (b,c,f,g)
Supermet Div., Globe Industries, Inc., Ohio (c,g)—Ad p 354
United Sintered Alloys, NY (a,b,c,f,g)
U.S. Graphite Co., Div. of Wickes Corp., Mich (b,c,d,f,g,j)
Uniworld Research Corp. of America, Ohio (c)
Veremere, E.A., Inc., Calif (a,b,c,f,g)
Wakefield Bearing Corp., Mass (b,c,f,g,h,j)
Wellman, S.K. Co., Ohio (b,c)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (a,b,c,f,g,h)
Yale & Towne Mfg. Co., Powdered Metal Products Div., Ill (b,c)

Metallic Coatings

(see Diffusion Coatings; Immersion Coatings; Galvanizers; Electroplaters; Hard Facing Alloys; Preplated Metals; Metallized Coatings)

Metallized Coatings—Spray Metallizers

Alloy Products Corp., Wis
Applied Instruments, Inc., NY
Bisonite Co., Inc., NY
Continental Boiler & Sheet Iron Works, Mo
Farwell Metal Fabricating, Minn
Firth Sterling, Inc., Pa
Flood City Brass & Electric Co., Pa
Hayden Wire Works, Inc., Mass
Haynes Stellite Co., Div. of Union Carbide Corp., Ind
Jema Chemical & Supply Co., NJ
Linde Co., Div. of Union Carbide Corp., NY
McGregor-Michigan Corp., Mich
Metal-Cladding, Inc., NY
Metallizing Co. of America, Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metallizing Engineering Co., Inc., NY —Ad p 128
Metalweld, Inc., Pa
Moore Dry Dock Co., Calif
New Jersey Zinc Co., NY
Parker White Metal Co., Pa —Ad p 333
Philadelphia Enameling Works, Inc., Pa
Sandy Hill Iron & Brass Works, NY
Schori Process Div., Ferro-Co Corp., NY
Schwartz Chemical Co., Inc., NY
Southern Galvanizing Co., Md
Superior Plating, Inc., Minn
Tickle, Arthur Engineering Works, Inc., NY —Ad p 290
Wall Colmonoy Corp., Stainless Process Div., Mich
Waterbury Cos., Inc., Conn
Zeller Corp., Ohio

Metallized Coatings—Vacuum Metallizers

Adams Plastic Products, Ohio
American Metal Climax, Inc., NY
Amos Molded Plastics Div., Amos-Thompson Corp., Ind
Applied Instruments, Inc., NY
Bee Chemical Co., Ill —Ad p 285
Closures, Inc., Conn
Coating Products, Inc., NJ —Ad p 291
Cohan Epner Co., Inc., NY
Cruver Mfg. Co., Ill
Davis Products Corp., NY
Dollin Corp., NJ
Electric Auto-Lite Co., Ohio
Erie Resistor Corp., Plastics Div., Pa
Eyelet Specialty Div., International Silver Co., Conn
Gomar Mfg. Co., Inc., NJ
Hastings & Co., Inc., Pa
High Vacuum Equipment Corp., Mass
International Optical Co., Inc., NY
Jema Chemical & Supply Co., NJ
Kinney Mfg. Div., N.Y. Air Brake Co., Mass
Metallizing Co. of America, Ill
Metaplast Process, Inc., NY
Rochester Div., Consolidated Electrodynamics Corp., NY
Schwartz Chemical Co., Inc., NY
Shelby Instrument Co., Calif
Superior Plastics, Inc., Ill
Swedlow Plastics Co., Calif
Sylvania Electric Products, Inc., NY

Metallized Coatings—Metallizing Wire

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Alloy Metal Wire Co., Inc., Pa
Alphaloy Corp., Div. of Alpha Metals, Inc., Ill
Armco Steel Corp., Ohio
Belmont Smelting & Refining Works, Inc., NY
Colonial Alloys Co., Pa
Crucible Steel Co. of America, Pa
Division Lead Co., Ill
Hayden Wire Works, Inc., Mass
Jones & Laughlin Steel Corp., Stainless Steel Div., Mich
Mariane Development Co., Inc., NY
Metal Goods Corp., Mo
Metallizing Co. of America, Ill
Metallizing Co. of Los Angeles, Inc., Calif
Metallizing Engineering Co., Inc., NY
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa
Roebling's, John A. Sons Corp., NJ
Rotometals, Calif
Uniworld Research Corp. of America, Ohio
Vanadium-Alloys Steel Co., Pa
Vandersee Corp., NJ
White Metal Rolling & Stamping Corp., NY

Methyl Methacrylate

(see Acrylic Plastics)

Mica

Asheville-Schoonmaker Mica Co., Va (r,z,aa,cc,ee)
Beryl Ores Co., Colo (z,aa,cc)
Concord Mica Corp., NH (aa)
Continental-Diamond Fibre Corp., Del (r,z,cc,ee)
Edgar Plastic Kaolin Co., Fla (aa)
Farnam Mfg. Co., NC (r)
Foote Mineral Co., Pa (aa)
Franklin Mineral Products Co., NC (aa)
Funkhouser Co., Md (aa)
General Electric Co., NY (r)
Hayden Mica Co., Inc., Mass (aa)
Industrial Mica Corp., NJ (f,cc)
Insulation Mfrs. Corp., Ill (r,cc,ee)
Mica Fabricating Co., NJ (r,aa,cc)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (z,cc,ee)
Micacraft Products, Inc., NJ (r,cc)
Mycalex Corp. of America, NJ (r,z,aa,bb,cc,dd)
Richmond Mica Corp., Va (aa)
Smith Chemical & Color Co., Inc., NY (aa)
Sylvania Electric Products, Inc., Parts Div., Pa (r)

Letters in ( ) indicate materials and forms—turn page for key

Synthetic Mica Co., Div. of Mycalex Corp. of America, NJ (aa)
U.S. Mica Co., Inc., Ill (r)

Mineral Wool

(see Inorganic Fibers)

Molding Compounds

(see specific plastic or rubber)

Moldings, Blow

American Hard Rubber Co., Div. of Amerace Corp., NJ (l)
Brown Rubber Co., Inc., Ind (m)
Cadillac Plastic & Chemical Co., Mich (k)
Continental Can Co., Inc., NY (k)
CrystalX Corp., Pa (k)
Davis, Joseph Plastics Co., NJ (k)
Foster Grant Co., Mass (k)
General Plastics Corp., Ohio (k)
General Plastics Mfg. Co., Wash (k,m)
Hohwieler Rubber Co., Inc., Pa (m)
Johnson Rubber Co., Ohio (m)
Lee Rubber & Tire Corp., Pa (m)
Luzerne Rubber Co., NJ (l)
Naige Co., Inc., NY (k)
Newth Rubber Co., RI (m)
Plax Corp., Conn (k)
Rogers Corp., Conn (m)
Schwab Plastic Corp., Mich (k,m)
Seamless Rubber Co., Conn (m)
Sheller Mfg. Corp., Mich (l,m)
Shoe Form Co., Inc., NY (k)
Stockwell Rubber Co., Inc., Pa (m)
Stokes Molded Products Div., Electric Storage Battery Co., NJ (l)
Sun Rubber Co., Ohio (m)
Swedlow Plastics Co., Calif (k,l)
Universal Unlimited, Inc., NY (k)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Whyte Mfg. Co., Inc., NY (k,m)

Moldings, Cold

Achushnet Process Co., Mass (m)—Ad p 220
American Hard Rubber Co., Div. of Amerace Corp., NJ (l)
American Insulator Corp., Pa (l)—Ad p 358
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Biggs, Carl H. Co., Inc., Calif (l)
Califbe, Co., Inc., Calif (l)
Ceilcote Co., Ohio (l)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Dumont Corp., Calif (l)
Enflo Corp., NJ (l)
Foss Mfg. Co., Plastics Div., Id (l)
Garfield Mfg. Co., NJ (l)
Halex Corp., Mich (k)
Heil Process Equipment Corp., Ohio (l)
Hohwieler Rubber Co., Inc., Pa (m)
Marblette Corp., NY (l)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (l)
Rostone Corp., Ind (l)
Seamless Rubber Co., Conn (m)
Schori Process Div., Ferro-Co Corp., NY (l)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (l)

Moldings, Compression

Acadia Synthetic Products Div., Western Felt Works, Ill (m)
Acushnet Process Co., Mass —Ad p 220
Admiral Corp., Molded Products Div., Ill (l)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (l)—Ad p 344
Allied Resinous Products, Inc., Ohio (k)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l,m)
American Insulator Corp., Pa (l)—Ad p 358
American Plastics Corp., NY (l)
American Sinterings Div., Engineered Plastics, Inc., Conn (l)
Anderson Assoc., Inc., Ohio (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Atlantic India Rubber Works, Inc., Ill (m)
Auburn Mfg. Co., Conn (k,m)
Auburn Plastics, Inc., NY (k,l)
Automotive Rubber Co., Inc., Mich (m)
Beck, I. & Sons, Inc., NY (k)
Belko Corp., Md (m)
Boonton Molding Co., NJ (k)
Camfield Fiberglass Plastics, Inc., Mich (l)
Canfield, H.O. Co., Va (l,m)
Chicago Gasket Co., Ill (l)
Chicago Molded Products Corp., Ill (l)
Chicago Rawhide Mfg. Co., Ill (k,m)—Ad pp 187-88
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (m)
Colonial Rubber Co., Ohio (k,m)
Colt's Plastics Co., Inc., Conn (l,m)
Conneaut Rubber & Plastics Co., Ohio (k,l,m)
Connecticut Hard Rubber Co., Conn (m)—Ad p 205
Consolidated Molded Products Corp., Pa (l)—Ad p 326
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
Crane Packing Co., Ill (k)
Davidson Rubber Co., Mass (l,m)
Dayton Rubber Co., Ohio (m)
Dimco-Gray Co., Ohio (l)
Disogrin Industries, Inc., NY (m)
Dixon Corp., RI (m)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Dumont Corp., Calif (l)
Electric Auto-Lite Co., Ohio (k,l)
Enflo Corp., NJ (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Faultless Rubber Co., Ohio (m)
Fiber Glass Industries, Inc., NY (l)
Fibercast Div., Youngstown Sheet & Tube Co., Okla (l)
Firestone Tire & Rubber Co., Ohio (m)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)—Ad p 361
Gatke Corp., Ill (l)
Geauga Industries Co., Ohio (m)
General American Transportation Corp., (Ill (l)
General Electric Co., Chemical & Metallurgical Div., Ill (l)
General Gasket, Inc., Conn (m)
General Industries Co., Molded Plastic Div., Ohio (l)
Glass Reinforced Plastics Corp., Ohio (l)
Glastic Corp., Ohio (l)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Goshen Rubber Co., Inc., Ind (m)—Ad p 332
Grimes Mfg. Co., Plastic Research Products Div., Ohio (l)
Haveg Industries, Inc., Del (l)
Hays Mfg. Co., Pa (l)
Hewitt Rubber Div., Hewitt-Robins, Inc., NY (m)
Hohwieler Rubber Co., Inc., Pa (m)
Insulation Products Co., Pa (l)
International Packings Corp., NH (m)
Jersey Plastic & Die Casting Co., NJ (l)
Johnson Rubber Co., Ohio (m)
Judsen Rubber Works, Inc., Ill (m)
Kuhn & Jacob Molding & Tool Co., NJ (l)
Kurz Kasch, Inc., Ohio (l)
Lee Rubber & Tire Corp., Pa (m)
Lewis, G.B. Co., Wis (l)—Ad p 336
Lone Star Plastics Co., Inc., Tex (l)—Ad p 356
Loranger Mfg. Corp., Pa (l)
Lunn Laminates, Inc., NY (l)
Luzerne Rubber Co., NJ (k,l)
Mack Molding Co., NJ (l)
Maloney, F.H. Co., Tex (l,m)
Martin Rubber Co., Inc., NJ (m)
Mesa Plastics Co., Calif (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (k,l,m)
Mid-States Rubber Products, Inc., Ind (l,m)
Midwest Molding & Mfg. Co., Ill (l)
Minnesota Rubber Co., Minn (l,m)
Molded Fiber Glass Co., Ohio (l)
Morrell, George Corp., Mich (l)
Newth Rubber Co., RI (m)
Panelyte Div., St. Regis Paper Co., NY (l)
Parker Appliance Co., Rubber Products Div., Ohio (m)
Parker Seal Div., Parker-Hannifin Corp., Ohio (m)
Parker, Stearns & Co., Inc., NY (m)
Perry Plastics, Inc., Pa (k,l)
Plastic Masters, Inc., Mich (l)
Plasticrafters, Inc., Ill (l)
Polymer Corp. of Pennsylvania, Pa (k)
Precision Rubber Products Corp., Ohio (m)
Prince Rubber Co., Inc., NY (k,l,m)
Quaker Rubber Div., H.K. Porter Co., Pa (l)
Raybestos-Manhattan, Inc., NJ (l,m)
Regal Plastic Co., Mo (l)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Resistoflex Corp., NJ (k)
Richardson Co., NY (l)
Rogers Corp., Conn (l,m)
Rogers, V.F. Plastic Molding, Colo (l,m)
Romar Plastics, Inc., Ill (l)
Rostone Corp., Ind (l)
Roth Rubber Co., Ill (l,m)
Russell Reinforced Plastics Corp., NY (l)
Sealview Plastics, Inc., Pa (l)
Shamban, W.S. & Co., Calif (k)
Shaw Insulator Co., NJ (l)
Sheller Mfg. Corp., Mich (k,l,m)
Southern Plastics Co., SC (l)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Stalwart Rubber Co., Ohio (m)
Standard Plastics Co., Mass (l)
Stockwell Rubber Co., Inc., Pa (k,l,m)
Stokes Molded Products Div., Electric Storage Battery Co., NJ (l)
Sun Rubber Co., Ohio (m)
Swedish Crucible Steel Co., Mich (k)
Swedlow Plastics Corp., Ohio (l)
Sylvania Electric Products, Inc., Parts Div., Pa (l)
Synthane Corp., Pa (l)
Toledo Industrial Rubber Co., Ohio (l,m)
Toyad Corp., Pa (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (l)
U.S. Stoneware Co., NY (k,l)
Vulcanized Rubber & Plastics Co., Pa (m)
Waterbury Cos., Inc., Conn (l)—Ad p 328
Wesbar Stamping Corp., Wis (m)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Whitso, Inc., Ill (l)
Williams-Bowman Rubber Co., Ill (l, m)
Woodall Industries, Inc., Mich (k,l)
Wyatt's Plastics, Inc., Tex (l,m)
Zenith Plastics Co., Calif (l)

Moldings, Injection

A & A Die Casting Co., Calif (k)
aaRBee Plastic Co., Calif (k)
Acushnet Process Co., Mass (m)—Ad p 220
Admiral Corp., Molded Products Div., Ill (k)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (k)—Ad p 344
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,m)
American Insulator Corp., Pa (k,m)—Ad p 358
American Plastics Corp., NY (k)
Amos Molded Plastics Div., Amos-Thompson Corp., Ind (k)
Anderson Assoc., Inc., Ohio (k)
Anthes Force Oiler Co., Iowa (k,l)
Auburn Mfg. Co., Conn (k,m)
Auburn Plastics, Inc., NY (k,m)
Auburn Rubber Co., Inc., Ind (k)
Belko Corp., Md (m)
Booker & Wallestad, Inc., Minn (k)
Boonton Molding Co., NJ (k)
Bridgeport Moulded Products, Inc., Conn (k)
Buckeye Molding Co., Ohio (k)
Burwood Products Co., Mich (k)
Byrd Plastics, Inc., Pa (k)
Campro Co., Ohio (k)
Canfield, H.O. Co., Va (l,m)
Carlon Products Corp., Ohio (k)
Celluplastic Corp., NJ (k)
Chicago Molded Products Corp., Ill (k)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (m)
Chippewa Plastics, Inc., Wis (k)
Clover Industries, Inc., NY (k)
Colonial Plastics Mfg. Co., Ohio (k)
Colt's Plastics Co., Inc., Conn (k)
Commercial Plastics Co., Associated Plastic Div., Mich (k)
Conneaut Rubber & Plastics Co., Ohio (k,l,m)
Consolidated Molded Products Corp., Pa (k)—Ad p 326
Continental Can Co., Inc., NY (k)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k)
Cruver Mfg. Co., Ill (k)
CrystalX Corp., Pa (k)
Dayton Rogers Mfg. Co., Minn (k,l)
Denver Plastics, Inc., Colo (k)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k,m)
Electric Auto-Lite Co., Ohio (k)
Engineered Nylon Products, Inc., Ind (k)
Erie Resistor Corp., Plastics Div., Pa (k)
Fiberfil, Inc., Ind (k)
Foster Grant Co., Mass (k)

Franklin Plastics, Inc., Pa (k)
Fry Plastics Co., Calif (k)
Galigher Co., Utah (k,l)
Garlock Packing Co., NY (k)—Ad p 361
Geauga Industries Co., Ohio (m)
General American Transportation Corp., Ill (k)
General Electric Co., Chemical & Metallurgical Div., Ill (k)
General Industries Co., Molded Plastic Div., Ohio (k)
Glass Laboratories, Inc., NY (k)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Gries Reproducer Corp., NY (k)
H & R Industries, Pa (k)
Hewitt Rubber Div., Hewitt-Robins, Inc., NY (m)
Hungerford Plastics Corp., NJ (k,m)
Jamison Plastic Corp., NY (k)
Jersey Plastic & Die Casting Co., NJ (k)
Jet Specialties Co., Inc., Calif (k)
Johnson Plastic Corp., Ohio (k,m)
Judsen Rubber Works, Inc., Ill (m)
Keolyn Plastics, Inc., Ill (k)
Kirk, F.J. Co., Inc., Mass (k)
Lancaster Glass Corp., Ohio (k)
Lee Rubber & Tire Corp., Pa (m)
Lone Star Plastics Co., Inc., Tex (k)—Ad p 356
Loranger Mfg. Corp., Pa (k)
Luminous Resins, Inc., Ill (k)
Luzerne Rubber Co., NJ (k)
Mack Molding Co., NJ (k)
Maloney, F.H. Co., Tex (k)
Michigan Plastic Products, Inc., Mich (k)
Midwest Molding & Mfg. Co., Ill (k)
Mimosa Corp., Ind (k)
Minnesota Plastics Corp., Minn (k,m)
Minnesota Rubber Co., Minn (l,m)
Naige Co., Inc., NY (k)
Norgren-Stemac, Inc., Colo (k)
Ohio Rubber Co., Ohio (k)
Panelyte Div., St. Regis Paper Co., NY (k)
Parker Seal Div., Parker-Hannifin Corp., Ohio (m)
Peoria Plastic Co., Ill (k)
Perfex Plastics, Inc., Ill (k)
Perry Plastics, Inc., Pa (k,l)
Pipco International Corp., Sub. of Plastiglide Mfg. Corp., Calif (k)
Plastic Engineering, Inc., Ohio (k)
Plastic Masters, Inc., Mich (k)
Plasticrafters, Inc., Ill (k,m)
Plax Corp., Conn (k)
Plymouth Industrial Products, Wis (k)
Porter, William Co., Calif (k)
Prince Rubber Co., Inc., NY (k,m)
Pyro Plastics Corp., NJ (k)
Raybestos-Manhattan, Inc., NJ (m)
Richardson Co., NY (k)
Rogers, V.F. Plastic Molding, Colo (k)
Romar Plastics, Inc., Ill (k)
Sanford Plastics Corp., NY (k)
Saran Lined Pipe Co., Mich (k)
Schwab Plastic Corp., Mich (k)
Shamban, W.S. & Co., Calif (k)
Shaw Insulator Co., NJ (k)
Sheller Mfg. Corp., Mich (k,l,m)
Sinko Mfg. & Tool Co., Ill (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Standard Plastics Co., Mass (k,m)
Sterling Molders, Inc., NY (k)
Stockwell Rubber Co., Inc., Pa (m)
Stokes Molded Products, Div. of Electric Storage Battery Co., NJ (l)
Superior Plastics, Inc., Ill (k)
Sylvania Electric Products, Inc., Parts Div., Pa (k)
Toledo Industrial Rubber Co., Ohio (l, m)
Tube Turns Plastics, Inc., Ky (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
United-Carr Fastener Corp., Mass (k,l)
Vulcanized Rubber & Plastics Co., Pa (k,m)
Wagner Plastic Corp., NJ (k)
Waterbury Cos., Inc., Conn (k)—Ad p 328
Western Felt Works., Ill (l,m)
Westlake Plastics Co., Pa (k)
Whyte Mfg. Co., Inc., NY (k,m)
Zenith Plastics Co., Calif (l)

Moldings, Reinforced Plastics

(see Laminates)

Moldings, Sheet

(sheet formed parts)

Allied Resinous Products, Inc., Ohio (k)
Allis Rubber Div., Chicago-Allis Mfg. Corp., Ill (m)
American Agile Corp., Ohio (k)
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
American Plastics Corp., NY (k)
Auburn Rubber Co., Inc., Ind (k)
Blank, Arthur & Co., Inc., Mass (k)
Borkland Mfg. Co., Ind (k)
Brown Rubber Co., Inc., Ind (m)
Cadillac Plastic & Chemical Co., Mich (k,l)
Canfield, H.O. Co., Va (l,m)
Capac Industries, Inc., Mich (k)
Carroll, J.B. Co., Ill (k)
Colonial Art Co., Inc., Mass (k)
Colonial Rubber Co., Ohio (k,m)
Connecticut Hard Rubber Co., Conn (m)
Consolidated Molded Products Corp., Pa (k)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (k,l)
CrystalX Corp., Pa (k)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Dura Plastics of New York, Inc., NY (k)
Enflo Corp., NJ (l)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Faige Engineering & Mfg. Div., Automation Corp., Md (k)
Fiber Glass Industries, Inc., NY (l)
Formica Corp., Sub. of American Cyanamid Co., Ohio (l)
Foster Grant Co., Mass (k)
Fry Plastics Co., Calif (k)
Galigher Co., Utah (k)
Garlock Packing Co., NY (k,m)—Ad p 361
General American Transportation Corp., Ill (k)
General Electric Co., Chemical & Metallurgical Div., Ill (m)
General Plastics Corp., Ind (k)
General Plastics Mfg. Co., Wash (k,m)
General Tire & Rubber Co., Ind (l)
Glastic Corp., Ohio (l)
H & R Industries, Pa (k)
Haveg Industries, Inc., Del (l)
Hays Mfg. Co., Pa (l)
Heil Process Equipment Corp., Ohio (l)
Hewitt-Robins, Inc., Conn (m)
Hohwieler Rubber Co., Inc., Pa (m)
Klise Mfg. Co., Mich (k)
Lone Star Plastics Co., Inc., Tex (k)
Luminous Resins, Inc., Ill (k)
Lunn Laminates, Inc., NY (k,l)
Lus-Trus Corp., Mich (k)
Luzerne Rubber Co., NJ (k,l)
Marblette Corp., NY (l)
Masland Duraleather Co., Pa (k)
Mica Insulator Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (k,l)
Midwest Plastic Products Co., Ill (k)
Minnesota Mining & Mfg. Co., Minn (l)
Naige Co., Inc., NY (k)
National Vulcanized Fibre Co., Del (l)
Newth Rubber Co., RI (m)
Nopco Chemical Co., NJ (l)
O'Sullivan Rubber Corp., Va (k)
Panelyte Div., St. Regis Paper Co., NY (k)
Pyro Plastics Corp., NJ (k)
Pyrosil, Inc., Ohio (l)
Quelcor, Inc., Pa (k)
Regal Plastic Co., Mo (k)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Rogers Corp., Conn (l,m)
Schori Process Div., Ferro-Co Corp., NY (l)
Sealview Plastics, Inc., Pa (k)
Seamless Rubber Co., Conn (m)
Shamban, W.S. & Co., Ind (k)
Shoe Form Co., Inc., NY (k)
Snyder Mfg. Co., Inc., Ohio (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Strick Plastic Co., Pa (k,m)
Superior Plastics, Inc., Ill (k)
Swedlow Plastics Co., Calif (k,l)
Synthane Corp., Pa (l)
Toyad Corp., Pa (k)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (k,l)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
Universal Unlimited, Inc., NY (k)
Valley-National Corp., Conn (k)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (m)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k)
Williams-Bowman Rubber Co., Ill (l,m)
Woodall Industries, Inc., Mich (k)
Wyatt's Plastics, Inc., Tex (k)

Moldings, Slush

(plastics and rubber)

American Agile Corp., Ohio (k)
Automotive Rubber Co., Inc., Mich (m)
Boonton Molding Co., NJ (m)
Borden Co., Chemical Div., NY (k)
Chemical Products Corp., RI
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (m)
Dennis Chemical Co., Mo (k)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Dumont Corp., Calif (l)
Hungerford Plastics Corp., NJ (k,m)
Minnesota Rubber Co., Minn (l,m)
Munray Products Div., Fanner Mfg. Co., Ohio (k,l,m)
Pyrosil, Inc., Ohio (l)
Sheller Mfg. Corp., Mich (k,l,m)
U.S. Stoneware Co., Ohio (k)
Wyatt's Plastics, Inc., Tex (k)

Moldings, Transfer

Accurate Molding Corp., NY (l)
Acushnet Process Co., Mass (m)—Ad p 220
Admiral Corp., Molded Products Div., Ill (l)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (l)—Ad p 344
American Hard Rubber Co., Div. of Amerace Corp., NJ (k,l)
American Insulator Corp., Pa (l)—Ad p 358
American Plastics Corp., NY (l)
American Sinterings Div., Engineered Plastics, Inc., Conn (l)
Auburn Mfg. Co., Conn (k)
Auburn Plastics, Inc., NY (l)
Automotive Rubber Co., Inc., Mich (m)
Belko Corp., Md (m)
Biwax Corp., Ill (l)
Booker & Wallestad, Inc., Minn (l)
Boonton Molding Co., NJ (k)
Bridgeport Moulded Products, Inc., Conn (l)
Canfield, H.O. Co., Va (l,m)
Chicago Molded Products Corp., Ill (l)
Chicago Rawhide Mfg. Co., Ill (k,m)—Ad pp 187-88
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (m)
Colonial Rubber Co., Ohio (k,m)
Colt's Plastics Co., Inc., Conn (l)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Consolidated Molded Products Corp., Pa (l)
Continental Rubber Works, Pa (m)
Dayton Rogers Mfg. Co., Minn (k,l)
Dayton Rubber Co., Ohio (m)
Dayton Rubber Co., Molded Products Div., Mich (l)
Dimco-Gray Co., Ohio (l)
Disogrin Industries, Inc., NY (m)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (k)
Faultless Rubber Co., Ohio (m)
Formica Corp., Sub. of American Cyanamid Co., Ohio (k)
Galigher Co., Utah (m)
Garfield Mfg. Co., NJ (l)
Garlock Packing Co., NY (k,m)—Ad p 361
General American Transportation Corp., Ill (l)
General Electric Co., Chemical & Metallurgical Div., Ill (l)
General Industries Co., Molded Plastic Div., Ohio (k)
Goodrich, B.F. Industrial Products Co., Ohio (k)
Grimes Mfg. Co., Plastic Research Products Div., Ohio (l)
Haveg Industries, Inc., Del (l)
Hewitt Rubber Div., Hewitt-Robins, Inc., NY (m)
Hohwieler Rubber Co., Inc., Pa (m)
Houghton, E.F. & Co., Pa (m)
Insulation Products Co., Pa (l)
Johnson Rubber Co., Ohio (m)
Judsen Rubber Works, Inc., Ill (m)
Kurz Kasch, Inc., Ohio (l)
Lee Rubber & Tire Corp., Pa (m)
Lone Star Plastics Co., Inc., Tex (l)
Loranger Mfg. Corp., Pa (l)
Luzerne Rubber Co., NJ (k,l)
Mack Molding Co., NJ (l)
Martin Rubber Co., Inc., NJ (m)
Mesa Plastics Co., Calif (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Mid-States Rubber Products, Inc., Ind (l,m)
Midwest Molding & Mfg. Co., Ill (l)
Minnesota Rubber Co., Minn (l,m)
Panelyte Div., St. Regis Paper Co., NY (l)
Parker Appliance Co., Rubber Products Div., Ohio (m)
Parker Seal Div., Parker-Hannifin Corp., Ohio (m)
Perry Plastics, Inc., Pa (l)
Plastic Research Products Co., Div. of Grimes Mfg. Co., Ohio (l)
Plasticrafters, Inc., Ill (l)
Porter, William Co., Calif (l)
Precision Rubber Products Corp., Ohio (m)
Raybestos-Manhattan, Inc., NJ (m)
Reinhold Engineering & Plastics Co., Inc., Calif (l)
Resistoflex Corp., NJ (k)
Richardson Co., NY (l)
Rogers, V.F. Plastic Molding, Colo (l,m)
Romar Plastics, Inc., Ill (l)
Rostone Corp., Ind (l)
Roth Rubber Co., Ill (m)
Seamless Rubber Co., Conn (m)
Shaw Insulator Co., NJ (l)
Sheller Mfg. Corp., Mich (k,l,m)
Southern Plastics Co., SC (l)
Standard Plastics Co., Mass (l)
Stockwell Rubber Co., Inc., Pa (m)
Stokes Molded Products, Div. of Electric Storage Battery Co., NJ (l)
Sun Rubber Co., Ohio (m)
Sylvania Electric Products, Inc., Parts Div., Pa (l)
Toledo Industrial Rubber Co., Ohio (l,m)
U.S. Rubber Co., Mechanical Goods Div., Ind (l)
Vulcanized Rubber & Plastics Co., Pa (m)
Waterbury Cos. Inc., Conn (l)—Ad p 328
Western Felt Works, Ill (l,m)
Whitso, Inc., Ill (l)
Williams-Bowman Rubber Co., Ill (l, m)
Wyatt's Plastics, Inc., Tex (l,m)

Molybdenum and Its Alloys

Alloy Metal Products, Inc., Iowa (o,w)
Alpha Metals, Inc., NJ (cc,dd)
Amalgamated Steel Corp., Ohio (o,bb)
American Metal Climax, Inc., NY (o,q,e,w,z,aa,bb,cc,dd)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Associated Engineering & Mfg. Corp., NJ (n,o,aa,bb,cc,dd,ee,ff)
Belmont Smelting & Refining Works, Inc., NY (o,w,aa)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (ff)
Bridgeport Brass Co., Conn (ee)
Cleveland Tungsten Inc., Ohio (aa)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,z,cc,dd)
Damascus Tube Co., Pa (ee)
Electro Metallurgical Co., NY (aa)
Elmet Div., North American Phillips Co., Inc., Me (o,w,z,aa,bb,cc,dd,ff)
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 138-39
General Electric Co., Lamp Wire & Phosphors Dept., Ohio (w,aa,bb,cc, dd,ff)
Hamilton Watch Co, Precision Metals Div., Pa (v,dd,ff)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (aa,ff)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Mallory, P.R. & Co., Inc., Ind (aa, bb)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Metal & Thermit Corp., NJ (w)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metallizing Engineering Co., Inc., NY (ff)
Molybdenum Corp. of America, Pa (o,w,z,aa,bb,cc,dd)
North American Phillips Co., Inc., Me (aa)
Oregon Metallurgical Corp., Ore (w)
Shieldalloy Corp., NJ (aa)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (n, w,aa,bb,ff)
Tube Distributors Co., Inc., NY (ee)
Universal-Cyclops Steel Corp., Pa (o,q, z,cc)
Utica General Jobbing Foundry, Inc., NY (aa)
Wah Chang Corp., NY (n,aa,bb,ff)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)

Monel

(see Nickel)

Neoprene

(see Chloroprene Rubber)

Nickel and Its Alloys

Advance Stamping Co., Miuh (dd)
Alloy Metal Powders, Inc., NY (aa)
Alloy Metal Products, Inc., Iowa (o, w)
Amalgamated Steel Corp., Ohio (o,bb)
American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp.,NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
American Sheet Metal Works, Inc., Conn (cc)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,w)
Auld, D.L. Co., Ohio (n)
Austenal, Inc., NY (w)
Bart Mfg. Corp., NJ (aa)
Belmont Smelting & Refining Works, Inc., NY (n,o,w,aa)—Ad p 130
Biddle Screw Products Co., Ind (bb, ee)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (ee,ff)—Ad p 324
Brinkerhoff Brass & Bronze Works, Inc., NY (cc,dd)
Brush Beryllium Co., Ohio (w)
Cannon-Muskegon Corp., Mich (o,v,w, cc,dd,ff)
Central Fabricators, Inc., Ohio (z, bb,cc,ee)
Chicago Steel Service Co., Ill (o,q,z, bb,cc,dd,ee,ff)
Crucible Steel Co. of America, Titanium and Vacuum Metal Products Div., Pa (o,q,v,z,bb,cc,dd,ee,ff)
Dahlin, C.A. Co., Ill (cc,ee)
Damascus Tube Co., Pa (ee)
Designers Metal Corp., Ill (cc)
Dixon Sintaloy, Inc., Conn (o)
Dormont Mfg. Co., Pa (ee)
Driver, Wilbur B. Co., NJ (b,dd,ff)—Ad p 131
Driver-Harris Co., NJ (v,bb,dd,ff)
Elgin National Watch Co., Abrasives Div., Ill (o,bb,dd,ff)
Erskine Precision Wire Corp., Pa (ff)
Federated Metals Div., American Smelting & Refining Co., NY (w)
Firth Sterling, Inc., Pa (o,q,w,bb,dd)
Foote Mineral Co., Pa (aa)
Fox Products Co., Pa (n)
Fromson Orban Co., Inc., NY (ee)
General Plate Div., Metals & Controls Corp., Mass (v,cc,dd)
Gibson Electric Co., Pa (bb,dd,ff)
Grand Rapids Brass Co., Mich (z)
Hamilton Watch Co., Precision Metals Div., Pa (v,w,bb,dd)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (aa,ff)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (o,q,v,z,bb,cc,dd, ee,ff)
Hoskins Mfg. Co., Mich (bb,dd)
International Nickel Co., Inc., NY (n,z,bb,cc,dd,ee,ff)—Ad pp 25-28
Jelliff, C.O. Mfg. Corp., Conn (ff)
K. & L. Plating Co., Pa (z)
Kanthal Corp., Conn (bb,dd,ff)
Kinkead Industries, Inc., Ill (cc,dd)
Lakeland Industries, Minn (z)
Lavin, R. & Sons, Inc., Ill (w)
Leach & Garner Co., Industrial Div., Mass (v,cc,dd,ee,ff)
McGean Chemical Co., Ohio (n,o,bb,dd)
Metal Forming Corp., Ind (ee)
Metal Goods Corp., Mo (o,z,bb,cc,dd, ee,ff)
Metal Hydrides, Inc., Mass (w,aa)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metallizing Engineering Co., Inc., NY (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Michigan Seamless Tube Co., Mich (ee)
Modern Plating Corp., Ill (n)
National Lead Co., NY (q,w)
National-Standard Co., Mich (ff)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Nesor Alloy Products Co., NJ (ff)
New England Brass Co., Mass (cc,dd)
New Jersey Metals Co., NJ (n,w)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Norwalk Powdered Metals, Inc., Conn (aa)
Oregon Metallurgical Corp., Ore (w)
Precision Tube Co., Inc., Pa (ee)
Pyron Corp., NY (aa)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Rigidized Metals Corp., NY (cc,dd)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (bb,dd,ff)
Rolock, Inc., Conn (ff)
Sandusky Foundry & Machine Co., Ohio (ee)
Sel-Rex Corp., NJ (n,aa)
Seymour Mfg. Co., Conn (n,bb,cc,dd,ff)
Shenango Furnace Co., Centrifugally Cast Products Div., Ohio (ee)
Shieldalloy Corp., NJ (aa)
Somers Brass Co., Inc., Conn (v,dd)—Ad pp 136, 139
Standard Metals Corp., Mass (ee)
Stevens, Frederic B., Inc., Mich (n)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa (ff)—Ad p 349
Techalloy Co., Inc., Pa (o,v,bb,cc,dd, ff)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Udylite Corp., Mich (n)
Ullmann, Inc., Wis (o,ee)
United Wire & Supply Corp., RI (ff)
Universal-Cyclops Steel Corp., Pa (o, q,z,bb,cc,dd,ff)
Utica General Jobbing Foundry, Inc., NY (aa)
Utica Metals Div., Kelsey-Hayes Co., NY (o,q,w,z,bb,cc,dd,ff)
Utility Mfg. Co., Mass (bb)
Vanadium-Alloys Steel Co., Pa (aa)
Walmet Alloys Co., Mich (w)—Ad p 72
Wall Colmonoy Corp., Stainless Process Div., Mich (w,aa,bb)
Wall Tube & Metal Products Co., Tenn (ee)
Wallingford Steel Co., Conn (dd,ee)—Ad p 352
Waterbury Rolling Mills, Inc., Conn (dd)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)
Whitehead Metal Products Co., Inc., NY (o,q,z,bb,cc,dd,ee,ff)
Wilson, H.A. Co., NJ (bb,dd)
Youngstown Welding & Engineering Co., Ohio (ee)

Nickel Silver

(see Copper)

Nitrides
(see Refractories)

Nitrile Rubber
(see Acrylonitrile-Butadiene Rubber)

Nodular Iron
(see Iron)

Nylon
(see Polyamides)

Organic Coatings
(formulations — lacquers, enamels, etc; see also Precoated Metals)

Abalon Precision Mfg. Corp., NY
Acme Plating Co., Ohio
Acme Stamping & Mfg. Co., Pa
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Allied Research Products, Inc., Md
—Ad p 281
Alpha-Molykote Corp., Conn
Amercoat Corp., Calif
American Cyanamid Co., Plastics & Resins Div., NY
American Solder & Flux Co., Pa
American-Marietta Co., Ill
Aries Laboratories, Inc., NY
Armitage, J.L. & Co., NJ
Ashtabula Mfg. Co., Ohio
Atlas Mineral Products Co., Pa
Auld, D.L. Co., Ohio
Automotive Rubber Co., Inc., Mich
Avondale Co., Ill
Babbitt Chemical Co., Inc., Mass
Barrett Varnish Co., Ill
Bee Chemical Co., Ill
—Ad p 285
Biggs, Carl H. Co., Inc., Calif
Bisonite Co., Inc., NY
Boatwright Paint & Varnish Works, Inc., Ga
Borden Chemical Div., Borden Co., NY
Bradley Paint Co., Pa
Bradley & Vrooman Co., Ill
Brandt, Charles T., Inc., Md
Burwood Products Co., Mich
Capitol Chemical Co., Ill
Carboline Co., Mo
Celicote Co., Ohio
Chemical Coatings Corp., Conn
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Chemical Process Co., Calif
Chemical Products Corp., RI
Commercial Chemical Co., Ohio
Cordo Chemical Corp., Conn
Davis Products Corp., NY
Day, James B. & Co., Ill
Dayton Rubber Co., Ohio
Debevoise Co., NY
Dennis Chemical Co., Mo
Designers Metal Corp., Ill
De Soto Paint & Varnish Co., Tex
Dirilyte Co. of America, Inc., Ind
Dollin Corp., NJ
Douglas & Sturgess, Calif
du Pont de Nemours, E.I. & Co., Inc., Del
Duralac Chemical Corp., NJ
Earl Paint Corp., NY
Egan & Hausman Co., Inc., NY
Egyptian Lacquer Mfg. Co., NJ
Electro Chemical Engineering & Mfg. Co., Pa
Electrofilm, Inc., Calif
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Everlite Corp., Wash
Fidelity Chemical Products Corp., NJ
Firestone Plastics Co., Pa
Flexrock Co., Pa
Forbes Finishes Div., Pittsburgh Plate Glass Co., Ohio
Fox Co., Ohio
Furane Plastics Inc., Calif
Gates Engineering Co., Del
General Electric Co., Chemical Materials Dept., Mass
General Plastics Corp., NJ
General Plastics Mfg. Co., Wash
Glidden Co., Ind
Globe Paint Works, Inc., Pa
Goodyear Tire & Rubber Co., Chemical Div., Ohio
Grand Rapids Varnish Corp., Mich
Hardman, H.V. Co., Inc., NJ
Haveg Industries, Inc., Del
Hilo Varnish Corp., Mass
Horn, A.C. Co., Inc., Div. of Sun Chemical Corp., NY
Houghton Laboratories, Inc., NY
Industrial Metal Protectives Inc., Ohio
Interchemical Corp., Finishes Div., NJ
Jamestown Finishes, NY
Jasper Lacquer Co., Inc., Ind
Johnson, S.C. & Son, Inc., Wis
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc., Ky
Keystone Refining Co., Inc., Pa
Kish Industries, Inc., Mich
Knight, Maurice A., Ohio
Lacquer Products, Inc., Ohio
Lakewood Metal Products, Inc., Conn
Landau, J. & Co., Inc., NJ
Lithcote Corp., Ill
Lowe Bros. Co., Ohio
Maas & Waldstein Co., NJ
Magnesium Co. of America, Ind
McDougall Butler Co., Inc., NY
Mearl Corp., NY
Merix Chemical Co., Ill
Metal & Thermit Corp., NJ
Micarta Div., Westinghouse Electric Corp., SC
Michigan Chrome & Chemical Co., Mich
Midland Industrial Finishes Co., Ill
—Ad p 285
Minnesota Mining & Mfg. Co., Adhesives & Coatings Div., Mich
Minnesota Paints, Inc., Minn
Minnesota Platon Corp., Minn
Mirro Aluminum Co., Wis
Mobile Paint Mfg. Co., Inc., Ala
Modern Plating Corp., Ill
Mono-Seal Products Div., Downer, Hunnewell, Inc., Mass
Monsanto Chemical Co., Organic Chemicals Div., Mo
—Ad p 283
Munray Products Div., Fanner Mfg. Co., Ohio
Narmco Resins & Coatings Co., Calif
Narragansett Boiler Works, Inc., RI
National Mfg. Corp., NY
National Polymer Products, Inc., Pa
Naugatuck Chemical Div., U.S. Rubber Co., Conn
New Jersey Zinc Co., NY
Nikolas, G.J. & Co., Inc., Ill
Nukem Products Corp., NY
Octagon Process, Inc., NY
Paramount Paint & Lacquer Co., Calif
Parker Paint Mfg. Corp., Ind
Pecora, Inc., Pa
Penn Metal Co., Inc., W.Va
Perry-Austen Mfg. Co., NY
Philadelphia Enameling Works, Inc., Pa
Pierce, F.O. Co., NY
Pierce & Stevens Chemical Corp., NY
Powell Pressed Steel Co., Ohio
Pratt & Lambert, Inc., NY
Promat Div., Poor & Co., Ill
Queen Products Co., Inc., Ky
Quelcor, Inc., Pa
Radiant Color Co., Calif
Raffi and Swanson, Inc., Mass
Randolph Products Co., NJ
Raybestos-Manhattan, Inc., NJ
Reynolds Chemical Products Co., Mich
Riegel Paper Corp., NY
Rinshed-Mason Co., Mich
Rodney Metals, Inc., NY
Rosco Laboratories, NY
Rubber Corp. of America, NY
Rust-Oleum Corp., Ill
Sauereisen Cements Co., Pa
Schori Process Div., Ferro-co Corp., NY
Schwartz Chemical Co., Inc., NY
Seal-Peel, Inc., Mich
Sealube Co., Mass
Seaporcel Metals, Inc., NY
Sherwin-Williams Co., Ohio
Simonsen Metal Products Co., Ill
Sprayiat Corp., NY
Stanley Chemical Co., Conn
Steel Protection & Chemical Co., Ind
Steelcote Mfg. Co., Mo
Subox, Inc., NJ
Sun Steel Co., Ill
Superior Plastics, Inc., Ill
Textileather Div., General Tire & Rubber Co., Ohio
Thermal Refractories Corp., NJ
Thompson and Co., Pa
Tousey Varnish Co., Ill
Tubular Rivet & Stud Co., Mass
Union Chemical Corp., NJ
Union Paste Co., Mass
U.S. Stoneware Co., Ohio
Waterbury Cos., Inc., Conn
Watson-Standard Co., Pa
Wesbar Stamping Corp., Wis
Western Coating Co., Mich
Westinghouse Electric Corp., Pa
Worth Co., Wis
Zeller Corp., Ohio
Zolatone Process, Inc., Calif

Organic Coatings
(coaters)

Aldan Rubber Co., Pa
Alloy Products Corp., Wis
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
—Ad p 344
American Emblem Co., Inc., NY
American Hard Rubber Co., Div. of Amerace Corp., NJ
Arbonite Corp., Pa
Aries Laboratories, Inc., NY
Ashtabula Mfg. Co., Ohio
Atlas Mineral Products Co., Pa
Auld, D.L. Co., Ohio
Automotive Rubber Co., Inc., Mich
Bee Chemical Co., Ill
Biggs, Carl H. Co., Inc., Calif
Bishopric Products Co., Ohio
Bisonite Co., Inc., NY
Boatwright Paint & Varnish Works, Inc., Ga
Bradley Paint Co., Pa
Brandt, Charles T., Inc., Md
Caspers Tin Plate Co., Ill
Chemical Development Corp., Mass
Coated Coil Corp., NY
Cohan Epner Co., Inc., NY
Colonial Alloys Co., Pa
Cordo Chemical Corp., Conn
Croname, Inc., Ill
Day, James B. & Co., Ill
Debevoise Co., NY
Dirilyte Co. of America, Inc., Ind
Dolin Metal Products, Inc., NY
Dollin Corp., NJ
Douglas & Sturgess, Calif
Earl Paint Corp., NY
Electric Auto-Lite Co., Ohio
Electro Chemical Engineering & Mfg. Co., Pa
Electro Technical Div., Sun Chemical Corp., NJ
Electrofilm, Inc., Calif
Emerson & Cuming, Inc., Mass
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Everlite Corp., Wash
Eyelet Specialty Div., International Silver Co., Conn
Falstrom Co., NJ
Farwell Metal Fabricating, Minn
Fletcher Enamel Co., W.Va
Forbes Finishes Div., Pittsburgh Plate Glass Co., Ohio
Foss Mfg. Co., Plastics Div., Id
Fuller, H.B. Co., Minn
Gates Engineering Co., Del
General Plastics Corp., NJ
Globe Paint Works, Inc., Pa
Goodrich, B.F. Industrial Products Co., Ohio
Grand Rapids Brass Co., Mich
Grand Rapids Varnish Corp., Mich
H & R Industries, Pa
Hartweld Co., Ohio
Haveg Industries, Inc., Del
Hayden Wire Works, Inc., Mass
Hilo Varnish Corp., Carpenter-Morton Co., Mass
Industrial Metal Protectives, Inc., Ohio
Jamison Plastic Corp., NY
Johnson, S.C & Son, Inc., Wis
Kelley Mfg. Co., Tex
Kickhaefer Mfg. Co., Wis
Lakewood Metal Products, Inc., Conn
Lithcote Corp., Ill
Lowe Bros. Co., Ohio
Maas & Waldstein Co., NJ
Magic Chemical Co., Mass
Marblette Corp., NY
Merix Chemical Co., Ill
Metal-Cladding, Inc., NY
Metalweld, Inc., Protective Coating Div., Pa
Met-L-Wood Corp., Ill
Michigan Chrome & Chemical Co., Mich
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich
Modern Plating Corp., Ill
Munray Products Div., Fanner Mfg. Co., Ohio
Montague Machine Co., Mass
Narmco Resins & Coatings Co., Calif
National Metal Products Co., Pa
Nikolas, G.J. & Co., Inc., Ill
Norgren-Stemac, Inc., Colo
Pecora, Inc., Pa
Polacoat, Inc., Ohio
Quelcor, Inc., Pa
Radiant Color Co., Calif
Raffi and Swanson, Inc., Mass
Respro Div., General Tire & Rubber Co., RI
Riegel Paper Corp., NY
Rustproofing & Metal Finishing Corp., Mass
Schori Process Div., Ferro-co Corp., NY
Schwartz Chemical Co., Inc., NY
Smoot-Holman Co., Calif
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio
Steelcote Mfg. Co., Mo
Sun Steel Co., Ill
Superior Plastics, Inc., Ill
Textileather Div., General Tire & Rubber Co., Ohio
Thermal Refractories Corp., NJ
Toyad Corp., Pa
Union Chemical Corp., NJ
U.S. Stoneware Co., Ohio
United-Carr Fastener Corp., Mass
Wayne Chemical Products Co., Mich
Woodstock Div., Electric Auto-Lite Co., Ill
Worth Co., Wis
Zolatone Process, Inc., Calif
Zophar Mills, Inc., NY

Letters in ( ) indicate materials and forms—turn page for key

Organic Coatings —Claddings

(see also Laminates, Metal-Organic)

American Hard Rubber Co., Div. of Amerace Corp., NJ
Arvin Industries, Inc., Ind
Automotive Rubber Co., Inc., Mich
Clad-Rex Corp., Ill
Electro Chemical Engineering & Mfg. Co., Pa
Lithcote Corp., Ill
Metal-Cladding, Inc., NY
National Polymer Products, Inc., Pa
Nukem Products Corp., NY
Penn Metal Co., Inc., W.Va
Seiberling Rubber Co., Plastics Div., Ohio
Sun Steel Co., Ill
Watson-Standard Co., Pa

Organic Coatings —Prepainted Metals

Abalon Precision Mfg. Corp., NY
Caspers Tin Plate Co., Ill
Clad-Rex Corp., Colo
Coated Coil Corp., NY
Cooley, W.J. & Co., Tenn
Dow Chemical Co., Mich
Electro Chemical Engineering & Mfg. Co., Pa
Enamelstrip Corp., Sub. of National Steel Corp., Pa
Falstrom Co., NJ
Fryling Mfg. Co., Pa
Hoofer Mfg. Co., Ill
Jones & Laughlin Steel Corp., Strip Steel Div., Ohio
Kaiser Aluminum & Chemical Sales Inc., Ill
Kees, F.D. Mfg. Co., Neb
Kinkead Industries, Inc., Ill
Lundquist Tool & Mfg. Co., Inc., Mass
Mahon, R.C. Co., Mich
National Metal Products Co., Pa
Olin Mathieson Chemical Corp., Aluminum Div., NY
Penn Metal Co., Inc., W.Va
Philadelphia Steel & Wire Corp., Pa
Republic Steel Corp., Ohio
Reynolds Aluminum Supply Co., Ga
Reynolds Metals Co., Va
Rigidized Metals Corp., NY
Rodney Metals, Inc., NY
Roll Coater, Inc., Ind
Security Sash & Screen Co., Mich
Sharon Steel Corp., Pa
Sun Steel Co., Ill
Thomas Strip Div., Pittsburgh Steel Co., Pa
—Ad pp 74-5

Organic Coatings, Strippable

Adhesive Products Corp., NY
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich
Amercoat Corp., Calif
American Latex Products Corp., Calif
Angier Adhesives Div., Interchemical Corp., Mass
Atlas Mineral Products Co., Pa
Babbitt Chemical Co., Inc., Mass
Bakelite Co., Div. of Union Carbide Corp., NY
Bee Chemical Co., Ill
—Ad p 285
Belding Corticelli Industries, NY
Better Finishes & Coatings, Inc., NJ
Bischoff Chemical Corp., Conn
Bisonite Co., Inc., NY
Blaco Mfg. Co., Ohio
Borden Chemical Div., Borden Co., NY
Carboline Co., Mo
Carey, Philip Mfg. Co., Ohio
Chemical Coatings & Engineering Co., Inc., Pa
Chemical Development Corp., Mass
Chemical Products Corp., RI
Daubert Chemical Co., Ill
Dennis Chemical Co., Mo
De Soto Paint & Varnish Co., Tex
Dip Seal Plastics, Inc., Ill
Diversey Corp., Metal Industries Div., Ill
Dow Chemical Co., Plastics Div., Mich
Earl Paint Corp., NY
Fidelity Chemical Products Corp., NJ
Fine Organics, Inc., NY
Frost Paint & Oil Corp., Minn
George, P.D. Co., Mo
Glidden Co., Ind
Globe Imperial Corp., Plastic-Seal Div., Ill
Houghton, E.F. & Co., Pa
Hughes Glue Co., Mich
Interchemical Corp., Finishes Div., NJ
Jamestown Finishes, NY
Johnson, S.C & Son, Inc., Wis
Jones-Dabney Co. Div., Devoe & Raynolds Co., Inc., Ky
Kinkead Industries, Inc. Ill
Koster-Keunen Mfg. Co. Inc. NY
Lacquer Products, Inc., Ohio
Landau, J. & Co., Inc., NJ
Maas & Waldstein Co., NJ
Metal & Thermit Corp., NJ
Micarta Div., Westinghouse Electric Corp., SC
Michelman Chemicals, Inc., Ohio
Midland Adhesive & Chemical Corp., Mich
Minnesota Mining & Mfg. Co., Adhesives, Coatings & Sealers Div., Mich
Minnesota Paints, Inc., Minn
Modern Plating Corp., Ill
Morningstar-Paisley, Inc., NY
Munray Products Div., Fanner Mfg. Co., Ohio
Nikolas, G.J. & Co., Inc., Ill
Nukem Products Corp., NY
Octagon Process, Inc., NY
Parker Paint Mfg. Corp., Ind
Pecora, Inc., Pa
Pennsalt Chemicals Corp., Pa
Pierce & Stevens Chemical Corp., NY
Poly Resins, Calif
Polyken Sales Div., Kendall Co., Ill
Polymer Chemical Co., Ohio
Protective Treatments, Inc., Ohio
Puritan Co., Inc., NY
Pyramid Plastics, Inc., Ill
Reynolds Chemical Products Co., Mich
Schwartz Chemical Co., Inc., NY
Seal-Peel, Inc., Mich
Servwell Products Co., Ohio
Sprayiat Corp., NY
—Ad p 278
Sun Steel Co., Ill
Texas Plastic Development Corp., Tex
Thompson and Co., Pa
Trim Alloys, Inc., Mass
Turco Products, Inc., Calif
Union Chemical Corp., NJ
Union Paste Co., Mass
U.S. Rubber Co., NY
U.S. Stoneware Co., Ohio
Valvoline Oil Co., Div. of Ashland Oil & Refining Co., Pa
Watson-Standard Co., Pa
Wayne Chemical Products Co., Mich
Western Coating Co., Mich
Whitfield Chemical Co., Mich
Xylos Rubber Co., Ohio
Zophar Mills, Inc., NY

Oxide Coatings

(see Conversion Coatings)

Oxides

(see Ceramics; Refractories)

Paints

(see Organic Coatings)

Papers

(cellulose, inorganic, synthetic; for industrial use)

Allied Chemical Corp., Plastics & Coal Chemicals Div., NY
Dexter, C.H. & Sons, Inc., Conn
Fasson Products, Ohio
Filpaco Industries, Inc., Ill
Fox Edge Co., Inc., Mass
General Gasket, Inc., Conn
Georgia-Pacific Corp., Ore
Gomar Mfg. Co., Inc., NJ
Hollingsworth & Vose Co., Mass
Insulation Mfrs. Corp., Ill
Johns-Manville Corp., NY
Knowlton Bros., Inc., NY
—Ad p 246
Mica Fabricating Co., NJ
Mosinee Paper Mills Co., Wis
—Ad p 250
National Gasket & Washer Mfg. Co., Inc., NY
Owens-Illinois Glass Co., Ohio
Panelyte Div., St. Regis Paper Co., NY
Precision Paper Tube Co., Ill
Raybestos-Manhattan, Inc., NJ
Riegel Paper Corp., NY
Rogers Corp., Conn
Spaulding Fibre Co., Inc., NY
—Ad p 217
Spruce Pine Mica Co., Inc., NC
Standard Asbestos Mfg. Co., Ill
Standard Washer & Mat, Inc., Conn
Twitchell, E.W. Inc., Pa
Vellumoid Co., Mass
Victor Mfg. & Gasket Co., Ill

Perforated Metals

Acme Precision Products, Inc., Ohio (a,b,g,h)
Aluminum Co. of America, Pa (a)
American Metal Products, Inc., Ohio (g)
American Nickel Alloy Mfg. Corp., NY (f)
American Sheet Metal Works, Inc., Conn (g)
Atlantic Steel Co., Ga (a,b,g)
BLC Porous Materials Co., Calif (a, b,e,f,g,j)
Biersach & Niedermeyer Co., Wis (a, b,c,f,g)
Blaco Mfg. Co., Ohio (b,g)
Brockway Pressed Metals, Inc., Pa (b, c)
Burgess-Norton Mfg. Co., Ill (c)
California Perforated Screen Co., Calif (a,b,c,f,g,j)
Caspers Tin Plate Co., Ill (g)
Chase Brass & Copper Co., Conn (b)
Clad-Rex Corp., Ill (a,g)
Clark Perforating Co., Mich (a,b,c,d, f,g,j)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Colorado Fuel & Iron Corp., Colo (g)
Cross Engineering Co., Pa (a,g)
Diamond Mfg. Co., Pa (a,b,c,d,e,f,g,h, j)
Duplex Mfg. Corp., NY (g)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Etched Products Corp., NY (a)
Falstrom Co., NJ (a,b,e,g)
Fletcher Enamel Co., W.Va (a,b,c,d,e, f)
Fox Products Co., Pa (c)
General Alloys Co., Mass (a,b,f,g)
Greene, G.G. Corp., Pa (g)
Harrington & King Perforating Co., Inc., Ill (a,b,c,d,e,f,g,h,j)—Ad p 341
Hawkridge Bros. Co., Mass (a)
Hendrick Mfg. Co., Pa (a,b,c,d,e,f,g,h, j)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Ideal Can Co., Mass (g)
Irwin Foundry & Mine Car Co., Industrial & Furnace Car Div., Pa (g)
Kees, F.D. Mfg. Co., Neb (g)
Levinson Steel Co., Pa (g)
Manganese Steel Forge Co., Pa (g)
McCarter Iron Works, Inc., Pa (g)
McNally Pittsburgh Mfg. Co., Kan (a, g)
Melco Wire Products, Calif (a)
Metal Goods Corp., Tex (a,b,f,g)
Mundt, Charles & Sons, NJ (a,b,c,d, e,f,g,h,j)
National Galvanizing Co., Pa (g)
National Lead Construction Co., Inc., NJ (d)
Norwalk Powdered Metals, Inc., Conn (b)
Parker Metal Goods Co., Mass (g)
Republic Steel Corp., Ohio (g)
Reynolds Metals Co., Va (a)
Rigidized Metals Corp., NY (a,b,f,g, h,j)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Servwell Products Co., Ohio (b,g)
Stainless Metals, Inc., NY (g)
Standard Stamping & Perforating Co., Ill (a,b,g)
Thompson Pipe & Steel Co., Colo (g)
Toepfer & Sons., Inc., Wis (a,b,c,e,f, g,h,j)
Wesbar Stamping Corp., Wis (a)
Whitehead Metal Products Co., Inc., NY (a,b,f)
Whyte, Oliver Co., Inc., NY (a,g)
Wire & Iron Products, Inc., Mich (f, g)

Permanent Mold Castings

(see Castings)

Phenolics

Ace Plastic Co., NY (bb,cc,dd)
Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (p)
American Reinforced Plastics Co., Conn (p,y)
Anderson Assoc., Inc., Ohio (y)
Archer-Daniels-Midland Co., Minn (y)
Atlas Mineral Products Co., Pa (x)
Auburn Plastic Engineering, Ill (bb,cc)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Bakelite Co., Div. of Union Carbide Corp., NY (p,u,x,y)
Bisonite Co., Inc., NY (x)
Blank, Arthur & Co., Inc., Mass (cc)
Borden Chemical Div., Borden Co., NY (p)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd,ee)
Calfibe Co., Inc., Calif (cc,ee)
Capac Industries, Inc., Mich (cc,dd)
Catalin Corp. of America, NY (p,x)
Chemical Process Co., Calif (x)
Coast Mfg. & Supply Co., Calif (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Consoweld Corp., Wis (cc)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (y)
Douglas & Sturgess, Calif (x,y)
Dunnican Assoc., NJ (p,y)
Durez Plastics Div., Hooker Chemical Corp., NY (p,x,y)—Ad pp 192-93
Electrofilm, Inc., Calif (t)
Eljay Corp., Md (bb,cc,dd,ee)
Falge Engineering Corp., Md (t)
Farley & Loetscher Mfg. Co., Plastics Div., Iowa (cc)
Fiber Glass Industries, Inc., NY (x,cc)
Fiberite Corp., Minn (y)

Formica Corp., Sub. of American Cyanamid Co., Ohio (bb,cc,dd,ee)
Galigher Co., Utah (bb,cc,dd,ee)
General Electric Co., Chemical Materials Dept., Mass (p,x,y)
General Electric Co., Laminated Products Dept., Ohio (bb,cc,ee)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Haveg Industries, Inc., Del (p,bb,cc, ee)
Hercules Powder Co., Inc., Del (p)
Iten Fibre Co., Ohio (bb,cc,dd,ee)
Lewis, J.P. Co., Plastic Products Div., NY (cc)
Kish Industries, Inc., Mich (u,x)
Kurz Kasch, Inc., Ohio (y)
Laminated Plastex Corp., Ohio (x,cc)
Loven Chemical of California, Calif (p,x,y)
Maloney, F.H. Co., Tex (x,y,bb,cc,dd, ee)
Marblette Corp., NY (p,u,x,y,bb,ee)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc,ee)
Micarta Div., Westinghouse Electric Corp., SC (p,x)
Monsanto Chemical Co., Plastics Div., Mass (p,x,y)
Narmco Resins & Coatings Co., Calif (u,x,y,dd)
National Moldite Co., NJ (y)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
New England Laminates Co., Inc., Conn (cc)
Nopco Chemical Co., NJ (p)
Norrich Plastics Corp., NY (bb,cc,dd, ee)
Northern Plastics Corp., Wis (cc,dd)
Omni Products Corp., NY (y)
Panelyte Div., St. Regis Paper Co., NY (x,bb,cc,dd,ee)
Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Plastic Engineering Co., Wis (p,x,y)—Ad p 202
Poly Resins, Calif (p,x)
Precision Paper Tube Co., Ill (ee)
Pyrosil Inc., Ohio (x,cc)
Quelcor, Inc., Pa (t)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (x)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (p,x,y)
Reichhold Chemicals, Inc., NY (p,x)
Reilly Tar & Chemical Corp., Ind (p,y)
Rezolin, Inc., Calif (p,u,x)
Richardson Co., NY (bb,cc,ee)
Rogers Corp., Conn (y)
Schenectady Varnish Co., Inc., NY (p, x)
Schwab Plastic Corp., Mich (bb,cc,dd, ee)
Spaulding Fibre Co., Inc., NY (bb,cc,dd,ee)
Strick Plastics Co., Pa (u,cc)
Sun Chemical Corp., Electro Technical Div., NJ (x)
Swedlow Plastics Co., Calif (cc)
Synco Resins, Inc., Conn (p,x)
Synthane Corp., Pa (bb,cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Texas Glass Fiber Corp., Tex (y)
Thombert, Inc., Iowa (bb,cc,dd,ee)
U.S. Polymeric Chemicals, Inc., Conn (s)
Varcum Chemical Corp., NY (p)
Watertown Mfg. Co., Conn (p,y)
Westlake Plastics Co., Pa (bb,cc,dd,ee)
Wilmington Fibre Specialty Co., Del (bb,cc,ee)

Phosphate Coatings

(see Conversion Coatings)

Phosphor Bronze

(see Copper)

Pipe

(see Tubing)

Plaster Mold Castings

(see Castings)

Plastics

(see specific material and form)

Plate

(see specific metal)

Plated Coatings

(see Electroplated Coatings; Preplated Metals)

Platinum and Platinum Group Alloys

American Metal Climax, Inc., NY (aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY (n,v,z,aa,bb,cc,dd,ee,ff)
American Platinum Works, NJ (z)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (o)
Baker & Co., Inc., NJ (n,o,v,w,z,aa, bb,cc,dd)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (n,v,w,cc,dd,ee,ff)—Ad p 324
Deringer Metallurgical Corp., Ill (cc, dd,ee,ff)
Eastern Smelting & Refining Corp., Mass (n,o,v,w,z,aa,bb,cc,dd,ee,ff)
General Plate Div., Metals & Controls Corp., Mass (n,v,z,bb,cc,dd)
Gibson Electric Co., Pa (bb,dd,ff)
Goldsmith Bros. Smelting & Refining Co., Ill (n,o,v,w,z,bb,cc,dd,ff)
Hagstoz, T.B. & Son, Pa (n,cc,dd,ff)
Hamilton Watch Co., Precision Metals Div., Pa (ff)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., Mass (aa)
Hayden Wine Works, Inc., Mass (ff)
Leach & Garner Co., Industrial Div., Mass (n,o,v,bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee,ff)
Metals & Controls Corp., Mass (n,o, q,v,w,z,aa,bb,cc,dd,ee,ff)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (z,bb,cc,dd,ff)
Sel-Rex Corp., NJ (n,aa)
Standard Metals Corp., Mass (cc,dd,ff)
Western Gold & Platinum Co., Calif (bb,cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)

Plywood

(see Wood)

Polyamides

(nylon)

Ace Plastics Co., NY (bb,dd)
Adhesive Products Corp., NY (x)
Allied Chemical Corp., NY (s)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,dd,ee)
American Molding Powder & Chemical Co., NY (y)
Anchor Plastics Co., Inc., NY (bb,dd,ee)
Anderson Asso., Inc., Ohio (y)
Aries Laboratories, Inc., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (y)
Bamberger, Claude P., Inc., NJ (y)
Belding Corticelli Industries, NY (p,x, y)
Catalin Corp. of America, NY (y)
Chemical Coatings & Engineering Co., Inc., Pa (x)
Chippewa Plastics, Inc., Wis (t)
Colonial Kolonite Co., Ill (bb,cc,dd,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd)—Ad p 182
Danielson Mfg. Co., Conn (bb,cc,dd,ee)
du Pont de Nemours, E.I. & Co., Inc., Del (p,s)
du Pont de Nemours, E.I. & Co., Inc., Polychemicals Div., Del (y)—Ad pp 195, 214-15
du Pont de Nemours, E.I. & Co., Inc., Textile Fibers Div., Del (s)
Emerson & Cuming, Inc., Mass (p,u,x)
Fiberfil, Inc., Ind (y)
Flexible Tubing Corp., Conn (ee)
Foster Grant Co., Mass (p,t,y,ee)
Fox Edge Co., Inc., Mass (s)
Fry Plastics Co., Calif (bb,cc)
General Mills Inc., Chemical Div., Ill (p)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Glass Laboratories, NY (bb,dd)
H & R Industries, Pa (t,bb,cc,dd,ee)
Houghton Laboratories, Inc., NY (x,y)
Industrial Rayon Corp., NY (s)
Moore, Samuel & Co., Ohio (ee)
Muehlstein, H. & Co., Inc., NY (y)
Narmco Resins & Coatings Co., Calif (x,y)
National Polymer Products, Inc., Pa (y)
National Vulcanized Fibre Co., Del (bb,dd,ee)—Ad p 225
Polymer Corp. of Pennsylvania, Pa (t, bb,cc,dd,ee)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x)
Reichhold Chemicals, Inc., NY (p)
Schwab Plastic Corp., Mich (bb,cc,dd, ee)
Southern Plastics Co., SC (bb,cc,dd, ee)
Spencer Chemical Co., Mo (p,x,y)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Thombert, Inc., Iowa (bb,cc,dd,ee)
U.S. Gasket Plastics Div., Garlock Packing Co., NJ (t,bb,cc,dd,ee)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (bb,dd,ee)
Western Plastics Corp., Neb (bb,dd,ee)
Westlake Plastics Co., Pa (t,bb,cc,dd, ee)

Polycarbonate Plastics

Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)
Electro Chemical Engineering & Mfg. Co., Pa (cc)
General Electric Co., NY (p,y)
Southern Plastics Co., SC (bb,cc,dd,ee)

Polyesters

Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (x)
Alsynite Co. of America, Calif (cc)
American Cyanamid Co., Plastics & Resins Div., NY (x)
American Metaseal Corp., NJ (p)
American Products Mfg. Co., Inc., La (p)
Archer-Daniels-Midland Co., Minn (p)
Atlas Mineral Products Co., Pa (x)
Atlas Powder Co., Chemicals Div., Del (p,x,y)—Ad p 203
Auburn Plastic Engineering, Ill (bb,cc)
Auburn Plastics, Inc., NY (bb,cc,dd, ee)
Bakelite Co., Div. of Union Carbide Corp., NY (p,x)
Boonton Molding Co., NJ (x)
Booty Resineers, Inc., NJ (p)
Brown Rubber Co., Inc., Ind (u)
Burkart, F. Mfg. Co., Div. of Textron Inc., Mo (u)
Cadillac Plastic & Chemical Co., Mich (t,x,cc)
Calfibe Co., Inc., Calif (cc,ee)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Cast Optics Corp., NJ (cc)

Celanese Corp. of America, Plastics Div., NJ (p)—Ad pp 183-86

Chemical Process Co., Calif (p,x,y)

Coating Products, Inc., NJ (t,cc)—Ad p 291

Colonial Kolonite Co., Ill (cc)

Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)

Cordo Chemical Corp., Conn (x,y)

Corrulux Div., L.O.F. Glass Fibers Co., Tex (cc)

Dayton Rubber Co., Ohio (x,y)

Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)

Douglas & Sturgess, Calif (x,y)

du Pont de Nemours, E.I. & Co., Inc., Del (p,s)

du Pont de Nemours, E.I. & Co., Inc., Film Div., Del (t)

du Pont de Nemours, E.I. & Co., Inc., Textile Fibers Div., Del (s)

Durez Plastics Div., Hooker Chemical Corp., NY (p,x,y)—Ad pp 192-93

Everlite Corp., Wash (cc)

Falge Engineering Corp., Md (t)

Fasson Products, Ohio (t)

Fiber Glass Industries, Inc., NY (x,y, cc)

Flexfirm Products, Calif (s,y)

Flexible Tubing Corp., Conn (ee)

Foamade Industries, Mich (u)

Foss Mfg. Co., Plastics Div., Id (p)

Fry Plastics Co., Calif (p,x)

Galigher Co., Utah (p,s,x)

General Electric Co., NY (x)

General Plastics Mfg. Co., Wash (x, cc)

General Tire & Rubber Co., Chemical Div., Ohio (p)

Glass Reinforced Plastics Corp., Ohio (bb,ee)

Glastic Corp., Ohio (u,y,bb,cc)

Glidden Co., Ind (p)

Goodrich, B.F. Co., Sponge Products Div., Conn (u)

Hall, C.P. Co., Ohio (p)

Haskelite Mfg. Corp., Mich (cc,dd)

Hastings & Co., Inc., Pa (t)

Haveg Industries, Inc., Del (cc)

Hays Mfg. Co., Pa (y,cc)

Heil Process Equipment Corp., Ohio (x,cc)

Interchemical Corp., NY (p,x,y)

Interchemical Corp., Finishes Div., NJ (p)

Kish Industries, Inc., Mich (x)

Laminated Plastex Corp., Ohio (x,cc)

Lewis, G.B. Co., Wis (y,bb,dd,ee)

Loven Chemical of California, Calif (p)

Luminous Resins, Inc., Ill (y)

Maloney, F.H. Co., Tex (x,y)

Micarta Div., Westinghouse Electric Corp., SC (p,y)

Minnesota Mining & Mfg. Co., Minn (s)

Mobay Chemical Co., Mo (p)

Muehlstein, H. & Co., Inc., NY (p)

Narmco Resins & Coatings Co., Calif (x,y,dd)

National Vulcanized Fibre Co., Del (cc)

Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)

Nopco Chemical Co., NJ (p)

Omni Products Corp., NY (p)

Ormond Mfg. Co., Inc., NJ (cc,dd)

Panelyte Div., St. Regis Paper Co., NY (x,y,cc)

Pelron Corp., Ill (p,x,y)

Penn Fibre & Specialty Co., Inc., Pa (cc)

Philrus Products Co., NJ (bb,cc,dd)

Pittsburgh Plate Glass Co., Pa (p)

Plumb Chemical Corp., Pa (y)

Polygon Plastic Co., Ind (bb,ee)

Porter, William Co., Calif (ee)

Precision Paper Tube Co., Ill (ee)

Reichhold Chemicals, Inc., NY (p,u,x)

Robertson, H.H. Co., Pa (p)

Rohm & Haas Co., Pa (x,y)

Rubber Corp. of America, NY (u)

Schori Process Div., Ferro-Co Corp., NY (cc,ee)

Schwab Plastic Corp., Mich (u)

Schwartz Chemical Co., Inc., NY (x)

Sheller Mfg. Corp., Mich (u)

Specialty Resins Co., Calif (p,x)

Strick Plastics Co., Pa (u,cc,dd)

Sun Chemical Corp., Electro Technical Div., NJ (p,x)

Swedlow Plastics Co., Calif (cc)

Texas Plastic Development Corp., Tex (p)

Thalco, Calif (p)

Thermaflow Chemical Corp., Pa (p)

Thiokol Chemical Corp., NJ (p)

United Shoe Machinery Corp., Mass (x)

U.S. Polymeric Chemicals, Inc., Conn (s)

U.S. Rubber Co., NY (p,u,x)

Varflex Corp., NY (ee)

Williamson Adhesives, Inc., Ill (y)

Witco Chemical Co., Ill (p,u)

Woodall Industries, Inc., Mich (y)

Zenith Plastics Co., Sub. of Minnesota Mining & Mfg. Co., Calif (u)

Polyethylenes

aaRBee Plastic Co., Calif (y)

Ace Plastic Co., NY (bb,cc,dd,ee)

Adhesive Products Corp., NY (x)

Advance Screw Products Co., Inc., Wis (bb)

Aladdin Products Co., NY (t,ee)

Allied Resinous Products, Inc., Ohio (y,bb,cc,dd,ee)

Alpha Wire Corp., NY (ee)

American Agile Corp., Ohio (bb,cc,dd, ee)

American Hard Rubber Co., Div. of Amerace Corp., NY (bb,dd)—Ad pp 196-7

American Molding Powder & Chemical Co., NY (y)

Anchor Plastics Co., Inc., NY (bb,dd,ee)

Anderson Asso., Inc., Ohio (y)

Anesit Co., Ill (ee)

Auburn Plastic Engineering, Ill (t,bb, cc)

Bakelite Co., Div. of Union Carbide Corp., NY (p,y)

Bamberger, Claude P., Inc., NJ (p,y)

Blacher, B., NY (t)

Blank, Arthur & Co., Inc., Mass (t)

Blossom Mfg. Co., Inc., NY (t,cc)

Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)

Campco Div., Chicago Molded Products Corp., Ill (t,cc)

Capac Industries, Inc., Mich (cc)

Carlon Products Corp., Ohio (t)

Carroll, J.B. Co., Ill (cc)

Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)

Catalin Corp. of America, NY (y)

Celanese Corp. of America, Plastics Div., NJ (p,t,y)—Ad pp 183-86

Celluplastic Corp., NJ (bb,ee)

Chester Packaging Div., St. Regis Paper Co., NY (t,cc)

Chippewa Plastics, Inc., Wis (t,ee)

Clopay Corp., Ohio (t,cc)

Clover Industries, Inc., NY (y)

Colonial Kolonite Co., Ill (bb,cc,ee)

Commercial Plastics & Supply Corp., NY (bb,cc,dd,ee)—Ad p 182

Conneaut Rubber & Plastics Co., Ohio (t,x,y,bb,cc,dd)

Contour Extrusion Co., NY (t,bb,cc,dd, ee)

Copper and Brass Sales, Inc., Mich (ee)

Coyne & Paddock, Inc., NY (y)

Crescent Plastics, Inc., Ind (ee)

CrystalX Corp., Pa (t,bb,cc,dd,ee)

Danielson Mfg. Co., Conn (bb,ee)

Dapol Plastics, Inc., Mass (y)

Davis, Joseph Plastics Co., NJ (t,y, bb,cc,dd,ee)

Denver Plastics, Inc., Colo (t,u,bb,cc, dd,ee)

Designers Metal Corp., Ill (cc)

Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)

Dow Chemical Co., Plastics Div., Mich (p,t,y)—Ad pp 189, 198

du Pont de Nemours, E.I. & Co., Inc., Del (p)

du Pont de Nemours, E.I. & Co., Inc., Polychemicals Div., Del (y)

Dura-Lee Corp., Mo (t)

Durethene Corp., Ill (t)

Eastman Chemical Products, Inc., Tenn (p,u,y)

Eclipse Plastic Industries, Inc., Fla (bb,cc,dd,ee)

Extruders, Inc., Calif (t)

Falge Engineering Corp., Md (t)

Fiberfil, Inc., Ind (y)

Firestone Plastics Co., Pa (t,bb)

Foss Mfg. Co., Plastics Div., Id (t)

Foster Grant Co., Mass (t)

Galigher Co., Utah (bb,cc,dd,ee)

Garlock Packing Co., NY (y)

Geauga Industries Co., Ohio (bb,dd)

General Electric Co., NY (t)

General Gasket, Inc., Conn (t,cc)

General Plastics Corp., Ind (cc)

General Plastics Mfg. Co., Wash (cc)

General Tire & Rubber Co., Ind (t,cc)

Genesee Laboratory, Inc., NY (ee)

Gering Products Inc., NJ (t,y)

Glass Laboratories, NY (bb,dd)

Goodrich-Gulf Chemicals, Inc., Ohio (p)

Grace, W.R. & Co., Polymer Chemicals Div., NJ (p,y)

H & R Industries, Pa (t,bb,cc,dd,ee)

Harte & Co., Inc., NY (t,cc)

Hastings & Co., Inc., Pa (t)

Hercules Powder Co., Inc., Del (p,y)

Hydrawlik Co., NJ (bb,dd)

Industrial Plastics Corp., Ind (bb,dd)

Jet Specialties Co., Inc., Calif (bb,cc, dd,ee)

KSH Plastics, Inc., Mo (bb,cc,dd)

Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (cc)

Koppers Co., Inc., Chemical Div., Pa (p,y)

Kuss, R.L. & Co., Inc., Ohio (t)

Luminous Resins, Inc., Ill (y)

Lus-Trus Corp., Mich (cc)

Maloney, F.H. Co., Tex (y)

Manufacturers Corp., Ohio (ee)

Mason Envelope Co., Inc., NY (t)

Mayon Plastics, Minn (ee)

Midwest Plastic Products Co., Ill (t, cc)

Molded Fiber Glass Co., Ohio (cc)

Monsanto Chemical Co., Plastics Div., Mass (p,y)

Moore, Samuel & Co.,Ohio (ee)

Muehlstein, H & Co., Inc., NY (y)

Murray, A.B. Co., Inc., NJ (ee)

Naige Co., Inc., NY (ee)

National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)

National Tube Div., U.S. Steel Corp., Pa (ee)

New England Tape Co., Inc., Mass (dd)

Olin Mathieson Chemical Corp., Film Div., NY (t,ee)

Omni Products Corp., NY (y)

Ormond Mfg. Co., Inc., NJ (cc,dd)

Pacific Coast Foil Co., Calif (t)

Panelyte Div., St. Regis Paper Co., NY (t,cc,ee)

Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)

Perfex Plastics, Inc., Ill (bb,dd,ee)

Phillips Chemical Co., Plastics Sales Div., Okla (p)—Ad pp 221-4

Plastic Materials, Inc., NY (y)

Plastic Packaging Co., Ill (t)

Plax Corp., Conn (t,cc)

Polo Plastics Co., Wis (t)

Polyplastic Products, Inc., NJ (t,cc)

Precision Paper Tube Co., Ill (cc)

Presto Plastic Products Co., Inc., NY (t,cc)

Pyramid Industries, Inc., Pa (ee)

Pyramid Plastics, Inc., Ill (bb,dd,ee)

Reed Plastics Corp., Mass (y)

Reliance Plastic & Chemical Corp., NJ (t,bb,dd)

Reynolds Aluminum Supply Co., Ga (t)

Reynolds Metals Co., Ky (t,cc)

Ross & Roberts, Inc., Conn (t)

Rubber & Plastics Compound Co., Inc., NY (t)

Russell Mfg. Co., Conn (s)

Schwab Plastic Corp., Mich (u,bb,cc, dd,ee)

Scranton Plastic Laminating Corp., Pa (cc)

Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)

Shaw-Kendall Engineering Co., Ohio (ee)

Sheller Mfg. Corp., Mich (u)

Shellmar-Betner Flexible Packaging Div., Continental Can Co., Inc., NY (t,cc)

Simon Products Co., Ill (t)

Snyder Mfg. Co., Inc., Ohio (t,cc)

Southern Plastics Co., SC (bb,cc,dd,ee)

Spencer Chemical Co., Mo (p,x,y)

Staver Co., Inc., NY (cc,dd)

Sunlites Plastics, Inc., Wis (bb,dd,ee)

Superior Plastics, Inc., Ill (bb,cc,dd, ee)

Supplex Co., Div. of Amerace Corp., NJ (y,dd,ee)

Technical Tape Corp., NY (t,cc,ee)

Thombert, Inc., Iowa (cc,ee)

Triangle Conduit & Cable Co., Inc., NJ (ee)

U.S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., NY (p,x,y)

U.S. Stoneware Co., NY (y)

Varflex Corp., NY (ee)

Visking Co., Plastics Div., Ind (t, cc)

Vogt Mfg. Corp., NY (bb,dd)

Vulcan Rubber Products Div., Reeves Bros., Inc., NY (s,bb,dd,ee)

Western Felt Works, Ill (cc)

Western Plastics Corp., Neb (bb,dd,ee)

Western Plastics Corp., Wash (ee)

Westlake Plastics Co., Pa (t,bb,cc,dd, ee)

Woodall Industries, Inc., Mich (cc)

World Plastex, NY (bb,cc,dd)

World Plastics, NY (bb,cc,dd,ee)

Polystyrenes

(incl. copolymers and modifications)

aaRBee Plastic Co., Calif (y)

Ace Plastic Co., NY (bb,cc,dd,ee)

Adhesive Products Corp., NY (x)

Ambassador Plastics & Mfg. Corp., Ill (u)

American Cyanamid Co., NY (y)

American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)—Ad pp 196-7

Anchor Plastics Co., Inc., NY (bb,dd,ee)

Anderson Asso., Inc., Ohio (y)

Anesit Co., Ill (ee)

Auburn Plastics, Inc., NY (bb,cc,dd, ee)

Bakelite Co., Div. of Union Carbide Corp., NY (p,y)

Bamberger, Claude P., Inc., NJ (p,y)

Blank, Arthur & Co., Inc., Mass (cc)

Cadillac Plastic & Chemical Co., Mich (x,bb,cc,dd,ee)

Campco Div., Chicago Molded Products Corp., Ill (t,cc)

Capac Industries, Inc., Mich (cc)

Catalin Corp. of America, NY (y)
Chemical Development Corp., Mass (p)
Chippewa Plastics, Inc., Wis (bb)
Coating Products, Inc., NJ (t,cc)
Colonial Art Co., Inc., Mass (cc)
Colonial Kolonite Co., Ill (bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc,dd)—Ad p 182
Conneaut Rubber & Plastics Co., Ohio (y,bb,cc,dd)
Crescent Plastics, Inc., Ind (ee)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Dapol Plastics, Inc., Mass (y)
Denver Plastics, Inc., Colo (u)
Dewey & Almy Chemical Co., Div. of W.R. Grace Co., Mass (p)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Dow Chemical Co., Plastics Div., Mich (p,t,u,y)—Ad pp 189, 198
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y)
Dumont Corp., Calif (u)
Dura Plastics of New York, Inc., NY (bb,cc)
Eclipse Plastic Industries, Inc., Fla (bb,cc,dd,ee)
Emerson & Cuming, Inc., Mass (u,x,bb)
Fiberfil, Inc., Ind (y)
Firestone Plastics Co., Pa (p)
Foster Grant Co., Mass (p,s,y,cc)
Fry Plastics Co., Calif (cc)
Galigher Co., Utah (bb,cc,dd,ee)
General Plastics Corp., Ind (cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
Gering Products Inc., NJ (y,bb,dd)
Glass Laboratories, NY (bb,dd)
Glo-Brite Products, Inc., Ill (u,y,cc)
Goodyear Tire & Rubber Co., Ohio (y)
H & R Industries, Pa (bb,cc,dd,ee)
Haskelite Mfg Corp., Mich (u)
Hayden Wire Works, Inc., Mass (x)
Industrial Plastics Corp., Ind (bb,dd)
KSH Plastics Inc., Mo (bb,cc,dd)
Kaykor Industries, Inc., NJ (cc)
Koppers Co., Inc., Chemical Div., Pa (p,u,y)
Laminated Plastex Corp., Ohio (x,cc)
Luminous Resins, Inc., Ill (y)
Lus-Trus Corp., Mich (cc)
Maloney, F.H. Co., Tex (x,y)
Manufacturers Corp., Ohio (ee)
Marbon Chemical Div., Borg-Warner Corp., Ind (p,y)—Ad pp 210-11
Midwest Plastic Products Co., Ill (t, cc)
Monsanto Chemical Co., Mass (p,y)
Muehlstein, H. & Co., Inc., NY (p,y)
Murray, A.B. Co., Inc., NJ (ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,y)
Nesbitt Industries, Inc., Ill (u)
Nixon Nitration Works, NJ (cc)
Northwest Plastics Industries, Inc., Wash (u)
Omni Products Corp., NY (y)
O'Sullivan Rubber Corp., Va (cc)
Panelyte Div., St. Regis Paper Co., NY (u,bb,cc)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Plastic Materials, Inc., NY (y)
Plax Corp., Conn (t,cc)
Polymer Corp. of Pennsylvania, Pa (bb,cc)
Precision Paper Tube Co., Ill (ee)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Reed Plastics Corp., Mass (y)
Schwab Plastic Corp., Mich (u,bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)
Sheller Mfg. Corp., Mich (u)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd,ee)
Strick Plastics Co., Pa (u)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,cc,dd, ee)
Toyad Corp., Pa (u)
United Shoe Machinery Corp., Mass (p,u)
U.S. Rubber Co., Royalite Div., NY (p)
Walsen Consolidated Mercantile Co., NY (y)
Western Felt Works, Ill (cc)
Western Plastics Corp., Neb (bb,dd,ee)
Western Plastics Corp., Wash (ee)
Westlake Plastics Co., Pa (t,y,bb,cc, dd,ee)
Woodall Industries, Inc., Mich (cc)
World Plastex, NY (bb,cc,dd)
World Plastics, NY (bb,cc,dd,ee)

Polysulfide Rubber

Adhesive Products Corp., NY (x)
Allis Rubber Div., Chicago-Allis Mfg. Corp., Ill (p)
Aries Laboratories, Inc., NY (p)
Armstrong Cork Co., Pa (bb,cc,dd)
Belko Corp., Md (y)
Boruski, Ernest F. Jr., NY (p)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (y)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Garlock Packing Co., NY (y,cc)
Home Rubber Co., NJ (y,bb,cc,dd)
Maloney, F.H. Co., Tex (y)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Raybestos-Manhattan Inc., Plastic Products Div., Conn (x)
Thiokol Chemical Corp., NJ (p,x,y)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y, bb,cc,dd,ee)

Polyvinyl Alcohols

(see Vinyls)

Polyvinyl Chloride and Copolymers

(see Vinyls)

Porcelain

(see Ceramics)

Porcelain Enamels

(see Inorganic Coatings)

Powdered Metals

(see Iron Powders or specific metal)

Precoated Metals —Aluminized

American Chain & Cable Co., Pa (g)
American Steel & Wire Div., U.S. Steel Corp., Ohio (g)
Armco Steel Corp., Ohio (g)
Bethlehem Steel Co., Pa (c,g)
Biersach & Niedermeyer Co., Wis (a)
Brasco Mfg. Co., Ill (g)
Clad-Rex Corp., Ill (a,g)
Colonial Alloys Co., Pa. (a)
Enamel Products Co., Ohio (g)
Gillett & Eaton, Inc., Minn (c)
Ideal Can Co., Mass (g)
Jackson Steel Products, Inc., NY (g)
Kees, F.D. Mfg. Co., Neb (g)
Mayville Metal Products Co., Wis (g)
National Galvanizing Co., Pa (g)
Olin Mathieson Chemical Corp., Aluminum Div., NY (a)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Sun Steel Co., Ill (g)
Tickle, Arthur Engineering Works, Inc., NY (c,g)—Ad p 290
U.S. Steel Corp., Pa (g)
Whitehead Metal Products Co., Inc., NY (g)
Whyte, Oliver Co., Inc., Mass (g)

Precoated Metals —Galvanized

Albert Pipe Supply Co., Inc., NY (g)
American Sheet Metal Works, Inc., Conn (g)
American Steel & Wire Div., U.S. Steel Corp., Ohio
Anderson-Bolling Mfg. Co., Mich (g)
Armco Steel Corp., Ohio (g)
Associated Spring Corp., Wallace Barnes Div., Conn (g)
Atlantic Steel Co., Ga (g)
Bethlehem Steel Co., Pa (c,g)
Biersach & Niedermeyer Co., Wis (g)
Bignall Co., NY (c)
Brasco Mfg. Co., Ill (g)
Brewer-Titchener, Corp., NY (g)
Clad-Rex Corp., Colo (g)
Conner Mfg. Co., Ky (g)
Continental Nu-Steel Metal Products Div., Continental Wire & Iron Works, Ill (g)
Continental Steel Works, Corp., Ind (g)
Edgcomb Steel & Aluminum Corp., NJ (g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Enterprise Galvanizing Co., Pa (g)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (c)
Granite City Steel Co., Ill (g)
Hobbs, Clinton E. Co., Mass (c,g)
Ideal Can Co., Mass (g)
Inland Steel Co., Ill (g)
Jackson Steel Products, Inc., NY (g)
Jones & Laughlin Steel Corp., Strip Steel Div., Pa (g)
Kaiser Steel Corp., Calif (g)
Kelley Mfg. Co., Tex (g)
Koehler Mfg. Co., Mass (c,g)
Kroh Wagner, Ill (g)
Levinson Steel Co., Pa (g)
Mahon, R.C. Co., Mich (g)
Mayville Metal Products Co., Wis (g)
McNally Pittsburg Mfg. Co., Kan (g)
Metal Goods Corp., Tex (g)
National Galvanizing Co., Pa (g)
National Tube Div., U.S. Steel Corp., Pa (g)
National-Standard Co., Mich (g)
New York Iron Roofing & Corrugating Co., Inc., NJ (g)
Newport Steel Corp., Ky (g)
Nikoh Tube Co., Ill (g)
Northwestern Steel & Wire Co., Ill (g)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Parker Metal Goods Co., Mass (g)
Republic Steel Corp., Ohio (g)
Riverside Foundry & Galvanizing Co., Mich (c,g)—Ad p 78-9
Roebling's, John A. Sons Corp., NJ (g)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Sharon Steel Corp., Pa (g)
Sherman & Reilly, Inc., Tenn (e,f,g)
Southern Galvanizing Co., Md (g)
Southern Metal Products Co., La (g)
Stenman, Bror F., Mass (g)
Sun Steel Co., Ill (g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (g)—Ad pp 74-5
U.S. Steel Corp., Pa (g)
Vulcan Rail & Construction Co., NY (g)
Weirton Steel Co., Div. of National Steel Corp., W.Va (g)—Ad p 71
Wesbar Stamping Corp., Wis (c,g)
Wheeling Steel Corp., W.Va (g)
Witt Cornice Co., Galvanizing Div., Ohio (g)
Worcester Wire Works Div., National-Standard Co., Mass (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Sheet & Tube Co., Ohio (g)

Precoated Metals —Lead or Terne-Coated

Acme Stamping & Mfg. Co., Pa (a, b,g)
American Brass Co., NY (b)
American Sheet Metal Works, Inc., Conn (g)
Anderson-Bolling Mfg. Co., Mich (g)
Armco Steel Corp., Ohio (c,g)
Biersach & Niedermeyer Co., Wis (g)
Brasco Mfg. Co., Ill (g)
Bridgeport Brass Co., Conn (b)
Cartwright, R. Tube Products Co., Mich (g)
Caspers Tin Plate Co., Ill (g)
Chase Brass & Copper Co., Conn (b)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Follansbee Steel Corp., Sheet Metal Specialty Div., W.Va (g)
Hayden Wire Works, Inc., Mass (d)
Higbie Mfg. Co., Mich (g)
Houston Blow Pipe & Sheet Metal Works, Tex (g)
Hussey, C.G. & Co., Div. of Copper Range Co., Pa (b)
Ideal Can Co., Mass (g)
Langsenkamp, F.H. Co., Ind (b)
Mallory-Sharon Metals Corp., Ohio (g)
Metal Goods Corp., Tex (b)
National Lead Construction Co., Inc., NJ (d)
New Haven Copper Co., Conn (b)
Nikoh Tube Co., Ill (g)
Philadelphia Steel & Wire Corp., Pa (g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Ryerson, Joseph T. & Son, Inc., (g)
Sandvik Steel, Inc., NJ (g)
Sharon Steel Corp., Pa (g)
Steel Protection & Chemical Co., Ind (a,b,c,f,g)
Sun Steel Co., Ill (g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (g)—Ad pp 74-5
U.S. Steel Corp., Pa (g)
Wayne Foundry & Stamping Co., Mich (g)
Weirton Steel Co., Div. of National Steel Corp., W.Va (g)
Wesbar Stamping Corp., Wis (c,g)
Wheeling Steel Corp., W.Va (g)

Letters in ( ) indicate materials and forms—turn page for key

Whitehead Metal Products Co., Inc., NY (b,g)
Wisconsin Tool & Stamping Co., Ill (g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)

Precoated Metals —Tin-Coated

Acme Stamping & Mfg. Co., Pa (a,b,g)
American Sheet Metal Works, Inc., Conn (g)
Anderson-Bolling Mfg. Co., Mich (g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Bethlehem Steel Co., Pa (c,g)
Brasco Mfg. Co., Ill (g)
Caspers Tin Plate Co., Ill (g)
Conner Mfg. Co., Ky (g)
Granite City Steel Co., Ill (g)
Inland Steel Co., Ill (g)
Jones & Laughlin Steel Corp., Strip Steel Div., Pa (g)
Kaiser Steel Corp., Calif (g)
Koehler Mfg. Co., Mass (c,g)
Lundquist Tool & Mfg. Co., Inc., Mass (a,g)
Philadelphia Steel & Wire Corp., Pa (g)
Republic Steel Corp., Ohio (g)
Riverside Foundry Co., Pa (c)
Smithers Tool & Machine Products, Inc., NY (g)
Somers Brass Co., Conn (b,f)
Steel Protection & Chemical Co., Ind (a,b,c,f,g)
Sylvania Electric Products, Inc., Parts Div., Pa (b)
Sun Steel Co., Ill (g)
U.S. Steel Corp., Pa (g)
Wabash Metal Products Co., Inc., Ind (g)
Weirton Steel Co., Div. of National Steel Corp., W.Va (g)
Wheeling Steel Corp., W.Va (g)
Wisconsin Tool & Stamping Co., Ill (g)
Youngstown Sheet & Tube Co., Ohio (g)

Pre-Impregnated Materials for Plastic Laminates

American Plastics Corp., NY (l)
American Reinforced Plastics Co., Conn (l)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Coast Mfg. & Supply Co., Calif (l)
Cordo Chemical Corp., Conn (k,l,m)
Eljay Corp., Md (k,l)
Emerson & Cuming, Inc., Mass (k,l,m)
Fabricon Products Div., Eagle-Picher Co., Mich (l)
Flexfirm Products, Calif (k,l)
Flexible Tubing Corp., Conn (k)
General Plastics Corp., NJ (k)
Haveg Industries Inc., Del (l)
Luminous Resins Inc., Ill (k)
Maloney, F.H. Co., Tex (l)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (l)
Micarta Div., Westinghouse Electric Corp., SC (l)
Minnesota Mining & Mfg. Co., Minn (l)
Modiglass Fibers, Inc., NJ (k,l)
Narmco Resins & Coating Co., Calif (l)
Panelyte Div., St. Regis Paper Co NY (l)
Raybestos Div., Raybestos-Manhattan, Inc., Conn (l)
Riegel Paper Corp., NY (k,l)
Rogers Corp., Conn (l)
Russell Mfg. Co., Conn (l)
Spaulding Fibre Co., Inc., NY (l)
Standard Insulation Co., Plastics Div., NJ (l)
Sun Chemical Corp., Electro Technical Div., (k,l,m)
Swedlow Plastics Corp., Calif (l)
U.S. Polymeric Chemicals, Inc., Conn (k,m)

Prepainted Metals

(see Organic Coatings)

Preplated Metals

(chromium, nickel)

Aluminum Co. of America, Pa (a)
Aluminum Specialty Co., Wis (a)
American Nickeloid Co., Ill (a,b,g,j)
American Silver Co., Inc., NY (b,f,g)
Apollo Metal Works, Ill (b,c,g,j)
Benjamin Electric Mfg. Co., Ill (g)
Chromalloy Corp., NY (g)
Enamelstrip Corp., Sub. of National Steel Corp., Pa (a,b,c,f,g,h,j)
Everard Tap & Die Corp., NY (a,b,c,g)
Fromson Orban Co., Inc., NY (a)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (a,b,c,e,f,g,h,j)
Hayden Wire Works, Inc., Mass (a,b,f,j)
Kroh Wagner, Ill (a,g)
Mechanical Steel Tubing Corp., NY (g)
Metal Trims, Inc., Miss (a)
National-Standard Co., Mich (g)
Republic Steel Corp., Ohio (g)
Rigidized Metals Corp., NY (a,g)
Roebling's, John A. Sons Corp., NJ (g)
Sun Steel Co., Ill (g)
Sylvania Electric Products, Inc., Parts Div., Pa (a,b,c,f,g)
Thomas Strip Div., Pittsburgh Steel Co., Pa (b,f,j)—Ad pp 74-5
Weirton Steel Co, Div. of National Steel Corp., W.Va (g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (g)
Worcester Wire Works Div., National-Standard Co., Mass (g)

Pressure Sensitive Tapes

(see tapes)

Protein Plastics

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
American Plastics Corp., NY (bb,cc)
Borden Co., Chemical Div., NY (p)
Chemical Process Co., Calif (x)
National Casein Sales, Ill (p)
Reichhold Chemicals, Inc., NY (p)

Quartz

(see Ceramics)

Refractories

American Insulator Corp., Pa (r)
Baxter Foundry & Machine Works, Inc., Id (r)
Carborundum Co., NY (r,z,bb,ee)—Ad p 244
Cedar Heights Clay Co., Ohio (r,aa)
Commercialores, Inc., SC (aa)
Coors Porcelain Co., Colo (r,z,bb,cc,ee)
Corning Glass Works, NY (r)
Dixon, Joseph Crucible Co., NJ (r)
Du-Co Ceramics Co., Pa (r,z,aa,bb,ee)
Electrical Refractories Co., Ohio (r, bb,ee)
Electro Refractories & Abrasives Corp., NY (r)
Emerson & Cuming, Inc., Mass (r)
Ferro Corp., Ohio (aa)
Foote Mineral Co., Pa (aa)
General Ceramics Corp., NJ (r)
General Refractories Co., Pa (r)
Gladding, McBean & Co., Calif (r)
Green, A.P. Fire Brick Co., Mo (r,s)
Haws Refractories Co., Pa (r)
Ironton Fire Brick Co., Ohio (r)
Laboratory Equipment Corp., Mich (r)
Louthan Mfg. Co., Div. of Ferro Corp., Ohio (r,z,bb,cc,ee)
Malvern Brick & Tile Co., Ark (r)
McCrady Refractories, Inc., Pa (aa)
Morganite, Inc., NY (r,ee)
North American Refractories Co., Ohio (r)
Norton Co., Mass (r,aa,ee)
Porter, H.K. Co., Inc., Refractories Div., Pa (r)
Refractory & Insulation Corp., NY (r,aa)
Refractory Specialties Co., Pa (r)
Sauereisen Cements Co., Pa (aa)
Shenango Refractories, Pa (r,z)
Thermal Refractories Corp., NJ (r, z,bb,cc,ee)
Thompson, H.I. Fiber Glass Co., Calif (s)
Wellsville Fire Brick Co., Mo (r)
Zirconium Corp. of America, Ohio (r, aa,bb,ee)

Reinforced Plastics

(see Laminates)

Rhenium

Chase Brass & Copper Co., Conn (aa,bb,dd)
Hardy, Charles, Inc., NY (aa)
Mallory, P.R. & Co., Inc., Ind (bb)
University of Tennessee, Dept of Chemistry, Tenn (aa)

Rock Wool

(see Inorganic Fibers)

Rod

(see specific material)

Rods, Welding

(see Filler Metals)

Roll Formed Parts

A & A Die Casting Co., Calif (a,b,g)
Abalon Precision Mfg. Corp., NY (a, b,c,g)
Acme Tube, Inc., NJ (a,b,c,g)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (g)—Ad p 344
Alloy Products Corp., Wis (a,f,g,h)
Alten Foundry & Machine Works, Inc., Ohio (g)
Aluminum Co. of America, Pa (a)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Nickel Alloy Mfg. Corp., NY (f)
American Pipe & Construction Co., Northwest Div., Ore (g)
Ampco Metal, Inc., Wis (b)
Arrow Metal Products Corp., NJ (a)
Beck, I. & Sons, Inc., NY (a,b,g)
Biersach & Niedermeyer Co., Wis (a, b,c,g)
Brush Beryllium Co., Ohio (b)—Ad p 130
Bunker Hill Co., Calif (d)
Burkhardt Steel Co., Colo (c,g)
Carbo Tool & Die Co., Ohio (c)
Carpenter Steel Co., Pa (g)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Craft Mfg. Co., Ill (f,g)
Crucible Steel Co. of America, Pa (g,h)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (h)
Dahlin, C.A. Co., Ill (a,b,f,g,j)
Day Co., Minn (a,g)
Dow Chemical Co., Magnesium Div., Mich (e)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (a,f,g,h)
Eaton Mfg. Co., Reliance Div., Ohio (g)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,f,g)
Enamel Products Co., Ohio (c)
Fabristeel Products, Inc., Mich (g)
Falstrom Co., NJ (a,b,e,g,h)
Fitzgibbons Boiler Co., Inc., NY (c)
Fletcher Enamel Co., W. Va (a,b,c,d,e, f,g)
Ideal Can Co., Mass (a,b,g)
Inland Steel Co., Ill (g)
Irwin Foundry and Mine Car Co., Pa (g)
Jackson Steel Products, Inc., NY (a, b,f,g,j)
Jones & Laughlin Steel Corp., Strip Steel Div., Ohio (g)
Kaiser Steel Corp., Calif (g)
Kelley Mfg. Co., Tex (a,b,g)
Kroh Wagner, Ill (a,b,c,f,g,j)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lock Joint Tube Co., Inc., Ind (g)
Magnesium Co. of America, Ind (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,c,e,f,g,h)
Manufacturers & Fabricators, Inc., Ohio (f,g)
McLanahan & Stone Corp., Pa (g)
Mechanical Steel Tubing Corp., NY (a, g)
Merrimac Brass, Mass (b,f)
Metal Forming Corp., Ind (a,b,e,f, g,h,j)
Midvale-Heppenstall Co., Pa (c,f,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
National Aluminum Co., Ohio (a,g)
National Metal Products Co., Pa (a, b,g,j)
National Screw & Mfg. Co., Ohio (b,g)
Nikoh Tube Co., Ill (g)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Pfister Aluminum Corp., NJ (a)
Posey Iron Works, Inc., Pa (g)
Pyramid Mouldings, Inc., Ill (a,b,c,g)
Regal Ware, Inc., Wis (a,b,g)
Revere Copper & Brass, Inc., Ill (a,b, c,f,g,j)
Reynolds Aluminum Supply Co., Ga (a)
Rockwell-Standard Corp., Stamping Div., NY (a,b,c,f,g)
Roll Formed Products Co., Ohio (a,b,e,g,j)—Ad p 337
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Security Sash & Screen Co., Mich (a)
Serrick Corp., John Lees Div., Ind (a,g)
Standard Pressed Steel Co., Pa (b,g)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (g)

Sylvania Electric Products, Inc., Parts Div., Pa (b,f,g)
Textron Metals Co., Ohio (a)
Thompson Pipe & Steel Co., Colo (a,b,c,d,e,f,g)
U.S. Steel Corp., Pa (g)
Vanadium-Alloys Steel Co., Pa (f)
Vulcan Mfg. Co., Ohio (a,b,c,f,g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Werner, R.D. Co., Inc., NY (a,b,g,j)—Ad p 346
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,e,f,g)
Wyatt Metal & Boiler Works, Inc., Tex (a,b,c,e,f,g)

Rubber, Natural

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NY (bb,cc,dd)—Ad pp 196-7
American Rubber Products Corp., Ind (u,bb,cc,dd,ee)
Atlas Mineral Products Co., Pa (cc)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc, dd)
Belko Corp., Md (y)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Colonial Rubber Co., Ohio (y)
Continental Rubber Works, Pa (bb,cc, dd,ee)
Coyne & Paddock, Inc., NY (cc)
Dayton Rubber Co., Ohio (u,y,bb,cc,dd, ee)
Douglas & Sturgess, Calif (x,y)
du Pont de Nemours, E.I. & Co., Inc., Del (cc)
Johns-Manville Corp., Dutch Brand Div., Ill (u,y,cc,dd)
Faultless Rubber Co., Ohio (u,y,bb,ee)
Foamade Industries, Mich (u)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
Geauga Industries Co., Ohio (y,bb,dd)
Goodrich, B.F. Chemical Co., Sponge Products Div., Conn (u)
Goshen Rubber Co., Inc., Ind (y)
Hardman, H.V. Co., Inc., NJ (x)
Hayes Adhesive Co., Inc., Mo (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd,ee)
Johns-Manville Corp., NY (cc)
Luzeane Rubber Co., NJ (bb,cc,dd)
Maloney, F.H. Co., Tex (y)
Martin Rubber Co., Inc., NJ (y,dd,eee)
Mid-States Rubber Products, Inc., Ind (y)
Morningstar-Paisley, Inc., NY (y)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (y, bb,cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Polymer Chemical Co., Ohio (x,y)
Rand Rubber Co., NY (p,t,cc)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,bb,cc,dd,ee)
Rogers Corp., Conn (y,cc,dd)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries, Inc., Va (u)
Rubber Corp. of America, NY (u)
Russell Mfg. Co., Conn (s)
Sheller Mfg. Corp., Mich (u)
Snyder, M.L. & Son, Inc., Pa (ee)
Standard Products Co., Mich (y)
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Technical Specialties Co., NY (dd)
Toyad Corp., Pa (t,u)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)—Ad p 216
U.S. Stoneware Co., NY (y)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y, bb,cc,dd,ee)

Rubber, Synthetic

(see specific material)

Sand Casting

(see Castings)

Sandwich Materials

(key letters refer to core materials)

Allegheny Ludlum Steel Corp., Pa (g)
Almco Steel Products Corp., Ind (g)
Aluminum Co. of America, Pa (a)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Armco Steel Corp., Ohio (g)
Artmor Plastics Corp., Md (l)
Bar-Ray Products, NY (d)
Busch, J.C. Co., NY (a,c)
Cadillac Plastic & Chemical Co., Mich (l)
Chemical Products Corp., RI (k)
Continental Rubber Works, Pa (m)
Dow Chemical Corp., Plastics Div., Mich (k)
Dumont Corp., Calif (a)
General Findings & Supply Co., Industrial Div., Mass (b,f)
General Tire & Rubber Co., Ind (l)
Glo-Brite Products, Inc., Ill (l)
H & R Industries, Pa (k)
Hardy Mfg. Corp., Ind (g)
Haskelite Mfg. Corp., Mich (k,l,m)
Hawkeye Rubber Mfg. Co., Iowa (k)
Hexcel Products, Inc., Calif (a,g)
Leach & Garner Co., Industrial Div., Mass (b,f)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Luminous Resins, Inc., Ill (k)
Lunn Laminates, Inc., NY (l)
Mechanical Rubber Products Co., NY (l)
Minnesota Mining & Mfg. Co., Minn (l)
National Moldite Co., NJ (c)
National Vulcanized Fibre Co., Del (l)
Northwest Plastics Industries, Inc., Wash (l)
Quaker Rubber Div., H.K. Porter Co., Pa (l)
Replac Corp., Ohio (k,l,m)
Rogers Corp., Conn (l,m)
Russell Mfg. Co., Conn (b)
Russell Reinforced Plastics Corp., NY (l)
Solar Aircraft Co., Calif (g,h)
Standard Insulation Co., NJ (l)
Standard Metals Corp., Mass (c,f)
Superior Steel Div., Copperweld Steel Co., Pa (g)
Swedlow Plastics Co., Calif (a,f,g,h)
Thompson, H.I. Fiber Glass Co., Calif (k)
West Haven Foundry Co., Conn (a,b)
Wittman, Lawrence & Co., NY (l)
Zenith Plastics Co., Calif (l)

Screw Machine Parts

Abalon Precision Mfg. Corp., NY (a, b,c,g)
Abbott Products, Inc., NY (a,b,c,d,e, f,g,h,j)
Advance Screw Products Co., Inc., Wis (a,b,c,g)
Aero Screw Co., Inc., Wis (b,c,f,g)
Affiliated Screw Products Co., Ill (a, b,c,d,e,f,g,h,j)
Aircraft Screw Machine Products Co., Ill (a,b,f,g)
Albany Products Co., Inc., Conn. (b,f)
Allied Machine Products Co., Mich (a,b,g)
Allied Metal Products Co., Mass (a, b,c,g)
Allied Products Corp., Mich (g)
Allmetal Screw Products Co., Inc., NY (f,g,h)
Aluminum Co. of America, Pa (a)—Ad p 331
American Electrical Products Co., Ohio (a,b,f,g)
American Fabricated Products Co., Ind (a,b,f,g)
American Sanitary Mfg. Co., Ill (b)
American Screw Products Co., Mich (a,b,g)
Ampco Metal, Inc., Wis (b)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Approved Mfg. Co., Inc., Mich (b,g)
Ar-Dee Screw Products Co., Inc., Mass (a,b,f,g)
Argosy Products, Inc., Ohio (a,b,g)
Ashby Mfg. Co., Mo (b,f,g)
Atlanta Tool Co., Ohio (a,b,f,g,h)
Auburn Spark Plug Co., Inc., NY (a, b,c,d,f,g,h)
Auel Industries, Pa (a,b,g)
Autel Electronics Co., Precision Machine & Welding Div., NJ (a,b,c,e, g,h)
Automatic Metal Products Corp., Mich (b,f,g,h)
Babson Dow Mfg. Co., Mass (a,b,c, f,g)
Balas Collet Mfg. Co., Ohio (a,b,f,g)
Baldwin Mfg. Co., Conn (a,b,c,d,f, g,h,j)
Barton Products Corp., Wis (a,b,c,e, f,g)
Bayley Products, Inc., Mich (a,b,g)
Beacon Metal Mfg. Co., NY (a,b,c,e, f,g,h,j)
Beck Products Corp., Mich (a,b,f,g)
Bell, David Co., Inc., NY (a,b,f,g,h)
Bethandale Corp., Ohio (a,b,f,g)
Bickford, F.H. Co., Ohio (a,b,g)
Biddle Screw Products Co., Ind (a,b, c,d,e,f,g,h)
Blacher Bros., Inc., RI (a,b,g)
Boehm Screw Products Co., Mich (a, b,f,g)
Boots Aircraft Nut Corp., Conn (a, b,f,g)
Brown Corp., NY (g)
Buchmann Spark Wheel Corp., NY (a, b,c,e,f,g)
Buckeye Brass & Mfg. Co., Ohio (b)
Burgess-Norton Mfg. Co., Ill (c)
C & G Screw Machine Products Co., Ind (a,b,g)
Carleton Screw Products Co., Minn (a, b,g)
Cartwright, R. Tube Products Co., Mich (a,b,g)
Cayce Corp., Ohio (a,b,g)
Central Screw Products Co., Mich (a, b,f,g)
Chapman Machine Co., Inc., Conn (a, b,f,g)
Chardon Metal Products Co., Ohio (a, b,f,g)
Chase Brass & Copper Co., Conn (a, b,f)
Chicago Screw Co., Div. of Standard Screw Co., Ill (a,b,c,f,g)
Clendenin Bros., Inc., Md (b)
Cleveland Cap Screw Co., Ohio (a,b, f,g,h)
Cleveland City Forge Co., Ohio (c,g)
Cleveland Hardware & Forging Co., Ohio (g)
Collis Co., Iowa (a,b,f,g)
Columbus Dental Mfg. Co., Ohio (a, b,c,g)
Columbus Jack Corp., Ohio (a,c,g)
Columbus Production Mfg. Co., Ohio (a,b,g)
Comerford Mfg. Co., Inc., Conn (a,b, c,e,f,g,h,j)
Condamatic Co., Inc., Mich (a,g,h)
Conn Perry Mfg. Co., Mich (b,g)
Connecticut Mfg. Co., Conn (b,f,g)
Control Parts Corp., NY (a,b,c,d,e,f, g,h,j)
Couch-Uthe Co., Ohio (b,f,g)
Curtis Products Co., Conn (a,b,c,f,g)
Curtis Screw Co., Inc., NY (a,b,f,g,h)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar polymers or gums
p—Base resins,
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Davis & Hemphill, Md (a,b,c)
Dawlen Corp., Mich (a,b,c,f)
Decatur Automatic Screw Machine Products Co., Ill (a,b,f,g)
Deerfield Mfg. Co., Ohio (a,b,f,g)
Defiance Screw Machine Products Div., Serrick Corp., Ohio (g)
Delo Screw Products Co., Ohio (a, b,f,g)
Dependable Automatic Screw Co., Conn (a,b,c,d,e,f,g,h,j)
Drexel Screw Products Co., Ill (a,b, c,d,f,g)
Duffin Mfg. Co., Ohio (a,b,g,h)
Duro Screw & Mfg. Co., NJ (a,b, f,g,h)
Eastern Machine & Screw Corp., Conn (a,g)
Economy Machine Products Co., Ill (a,b,f,g)
Electric Auto-Lite Co., Ohio (a,b,c,g)
Electric Materials Co., Pa (b)
Electronic Parts Mfg. Co., NJ (c,g)
Elsby, J.S., Inc., Wis (a,b,f,g)
Enoch Mfg. Co., Ore (a,b,c,e,g,j)
Essential Bar Products Co., Mich (a, b,f,g)
Eureka Electric Products Co., Pa (a,b)
Everard Tap & Die Corp., NY (a,b,c, f,g)
Fairchild Screw Products, Inc., Conn (a,b,f,g)
Falls Machine Co., Ohio (a,b,g)
Federal Screw Works, Mich (a,b,f,g)
Femco Mfg. Co., Inc., Mich (g)
Fetcher, M.B. Co., Mich (g)
Fischer Special Mfg. Co., Ohio (a,b)
Fordsell Machine Products Co., Mich (b,f,g)
Frisby, R.J. Mfg. Co., Ill (a,b,g)
G & G Mfg. Co., Ill (a,b,f,g)
G & Z Automatic Products Co., Mich (a,b,g)
Gantner Screw Products Co., Inc., Ohio (a,b,f,g)
General Engineering Works, Ill (a,b,f, g)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
General Screw Products Corp., NY (a, b,f,g)
Grass, M.J. Machine Products Co., NY (a,b,f,g)
Greer Stop Nut Co., Ill (a,b,c,e,f,g,h, j)
Gregg Metal Products Co., Wis (a,b, f,g)
Gross, Willard N., Inc., NJ (a,b,f,g)
H & H Screw Products, Inc., NY (a, b,f,g,h)
H & H Screw Products Mfg. Co., RI (a,b,f,g)
H & K Machine Service Co., Inc., Mo (a,b,g)
Haber Corp., Ill (a,b,c,f)
Hack, J.H. Mfg. Co., Mich (a,b,f,g)
Hardy Mfg. Corp., Ind (a,b,g)
Harvey Aluminum Div., Harvey Machine Co., Inc., Calif (a,g)
Harvin & Co., NJ (a,b,f,g)
Harwood Screw Products, Inc., Ohio (a,b,g)
Held, O.P., Inc., NY (a,b,c,g)
Heller, A.B. Screw Products, Inc., Mich (a,b,g)
Henefelt Precision Products, Ohio (a, b,f,g)
Hercules Fastener Co., Ill (a,c,f,g,j)
Herker Screw Products, Inc., Wis (a,b, g)
Herman Machine & Tool Co., Ohio (a, b,f,g)
Hershey Metal Products, Inc., Conn (a,b,f,g,h)
Holt Products Co., Mich (a,g)
Hoofer Mfg. Co., Ill (a,c)
Hoyt, Charles D. Co., Inc., Ind (a, b,f,g)
Huck Mfg. Co., Mich (a)
Hudson Screw Machine Products Co., Ill (a,b,c,e,f,g,h,j)
Hunt Screw & Mfg. Co., Ill (a,b,f,g,h)
Huron Automatic Screw Co., Mich (a,b,g)
Hy-Level Screw Products Co., Ohio (a, b,g)
Ideal Metal Products Co., Ill (a,b,f,g)
Imsande Screw Products Co., Ohio (a, b)
Industrial Precision Products, Ill (a,b, c)
Industrial Screw Machine Products Co., Ill (a,b,f,g)
Inland Mfg. Co., Neb (a,b,c,d,e,f,g,h,j)
Instrument Parts Corp., NY (a,b,c,f,g)

Instrument Specialties Co., Inc., NJ
(b)—Ad p 343

Jaques Co., Mass (a,b,e,f,g,h)
Jolens Metal Products Co., NJ (a,b,f, g)
Jordan Machine Products, Inc., Mich (a,b,f,g)
Kay-Bee Machine Products Co., Wis (a,b,g)
Kennedy Automatic Products, Inc., Mich (a,b,g)
Kenosha Automatic Products Co., Wis (a,b,g)
Kerr-Lakeside Industries, Inc., Ohio (a,b,f,g)
Kewaunee Engineering Corp., Wis (c)
Klincher Locknut Corp., Ind (a,b,c,f,g)
Koehler Mfg. Co., Mass (c)
Kohn Engineering Corp., Mich (a,b,c, f,g,h)
Kramer, C.P. Co., Ill (a,f,g)
Lake Mfg. Corp., Conn (a,b,g)
Lamson Products Co., Wash (a,b,f,g)
Lattner Bros. Machining Co., Mich (a, b,f,g)
Latwaitis, Ernest A., NY (a,b,f,g)
Lawrenceville Screw Co., Pa (a,b,f,g)
Lincoln Machine Parts Corp., NY (a, b,f,g,h)
Lincoln Mfg. Co., Inc., Ill (a,b,f,g)
Linden & Co., Inc., RI (a,b,c,g)
Livingston-Tyler Products, Ohio (a,b, e,g)
Locke Machine Co., Ohio (a,g)
Loeffler, J.M. Co., Machine & Brass Works, Pa (a,b,c)
Lorain Automatic Screw Machine Co., Inc., Ohio (a,b,g)
Lubenow, Arthur Co., Wis (a,b,f,g)
Lundberg Screw Products Co., Mich (a, b,g)
Lyndon Machine Products Co., Inc., Mich (a,b,g)
M & S Mfg. Co., Mich (a,b,g)
Machine Products Corp., Ohio (a,b,c, d,e,f,g,h,j)
Machinery Products Co. of Lancaster, Pa (a,b,f,g)
Machinery Products Corp., Ill (a,b,f,g)
Mac-It Parts Co., Pa (b,f,g)
Main Screw Machine Products, Inc., Conn (a,b,g)
Mantel Screw Products Co., Wis (a, b,f,g,h)
Marquette Metal Products Co., Ohio (a,b,f,g)
Masco Screw Products Co., Mich (a, b,f,g)
Massachusetts Screw Mfg. Co., Mass (a,b,f,g)
Maumee Machine & Tool Corp., Ohio (a,b,f,g)
Maynard Mfg. Co., Mich (a,b,f,g,h)
McKinney Mfg. Co., Pa (a,b,e,f,g)
McLanahan & Stone Corp., Pa (c,g)
McMahon Bros. Machine Works, Inc., Ill (a,b,f,g,h)
Meaden Screw Products Co., Ill (a, b,f,g)
Measuregraph Co., Mo (a,b,f,g,h)
Mechanical Art Works, Inc., NJ (a,b, f,g)
Meier Screw Products & Mfg. Co., Mich (a,b,c,e,f,g)
Merit Screw Machine Products Co., Ill (a,b,f,g,h)
Merit Specialties Co., Inc., Mo (a,b, e,f,g)
Merz Machine & Tool Works, Ind (a, b,g)
Micro Products Corp., Mo (a,g)
Mid-West Screw Products Co., Mo (a, b,c,g)
Midwest Screw Products, Inc., Ohio (a,b,f,g,h)
Milford Automatics, Inc., Conn (a,b,g)
Milled Screw Products, Co., Ill (a,b, f,g)
Millers' Brass Fitting Co., Inc., NY (a,b,f,g)
Milwaukee Machine Products Co., Wis (a,b,g)
Milwaukee Stamping Co., Wis (a,g)
Mitchell & Scott Machine Co., Inc., Ind (a,b,f,g)
Modern Screw Products Co., Mo (b, f,g)
Monarch Tool & Mfg. Co., Ky (g)
Moody Machine Products Co., Inc., RI (a,b,g)
Moore, George W., Inc., Mass (a,b,g)

Mueller Brass Co., Mich
(a,b,f)—Ad p 357

Mueller Machine Products Inc., Wis (a,b,c,d,e,f,g,j)
Napoleon Products Co., Ohio (a,g)
National Acme Co., Ohio (a,b,f,g)
National Lead Co., NY (a)
National Screw & Mfg. Co., Ohio (b, f,g)
Naugatuck Automatics, Inc., Conn (a, b,g)
New Britain Machine Co., Conn (a,b,g)
New Haven Screw Machine Products, Inc., Conn (a,b,f,g,h,j)
Newtown Mfg. Co., Conn (a,b,f,g,h)
Nicoud Mfg. Co., Ill (a,b,f,g)
Noera Mfg. Co., Conn (a,b,g)
Nolte Screw Machine Products Co., Ohio (a,b,c,f,g)
Northwest Automatic Products Corp., Minn (a,b,f,g)
Northwestern Machine Corp., Mo (a, b,f,g)
Nutmeg Screw Machine Products Co., Conn (a,b,f,g)
Ohio Metal Products Co., Ohio (a,b, f,g,h)
Ohio Screw Products, Inc., Ohio (a, b,f,g)
Olderman Mfg. Corp., Conn (a,b)
Olson Mfg. Co., Mass (a,b,f,g)
Orange Roller Bearing Co., Inc., NJ (g)
Ostby & Barton Co., Flightex Fabrics, Inc., RI (a,b,f,g)
Ottawa Steel Products, Inc., Mich (g)
Owen Mfg., Inc., Ill (a,b,f,g)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g,h,j)
Pacific Screw Products Co., Calif (a, b,f,g)
Pan-American Metal Products Co., Inc., Fla (a,b,f,g)
Parker & Harper Mfg. Co., Mass (a, b,f,g)
Peck Spring Co., Conn (a,b,c,f,g)
Peerless Automatic Machine Co., Ohio (a,b,c,g)
Peerless Industries, Inc., Mich (a,b,g)
Peerless Products Industries, Ill (a,b, g)
Perry Fay Co., Ohio (a,b,g)
Phillips, F.C., Inc., Mass (b,f,g)
Phillips Bros. Screw Products Co., Mich (b,f,g,h)
Piper Tool Co., Inc., Mich (g)
Pohlman, R.L. Co., Mo (a,b,g)
Polyphase Machine Co., NY (a,b,f,g,h)
Precision Machine Co., Ind (a,b,g)
Precision Piece Parts, Inc., Ind (g)
Precision Screw Products Co., Inc., Calif (a,b,f,g)
Progressive Service Co., Mo (a,b,e,f, g)
Racine Screw Co., Wis (a,b,f,g)
Rainier Metal Products Co., Ill (a,b, g)
Rasco-Veeder Co., Ill (a,b,f,g)
Ravenswood Machine Corp., Ill (a,b, f,g)
Red Devil Mfg. Co., Ill (a,b,c,d,e,f, g,h,j)
Redmer Air Devices, Ala (a,b,c,f,g)
Reliable Screw Machine Products, Ill (a,b,f,g,h)
Remler Co., Ltd., Calif (a,b,f,g)
Rex Products Co., Ohio (a,b,f,g)
Richmond Mfg. Co., Tex (b,f,g)
Rosan Inc., Calif (a,g)
S & S Mfg. Co., NJ (a,b,c,e,f,g,h)
Sargent & Greenleaf, Inc., NY (a,b,g)

Scovill Mfg. Co., Mill Products Div., Conn
(a,b)

Searjeant Metal Products, Inc., NJ (a, g)
Seltzer, George H. & Co., Pa (g)
Sharpsville Steel Fabricators, Inc., Pa (g)
Sheller Mfg. Corp., Mich (g)
Sinclair Co., Mass (a,b,g)
Skookum Co., Inc., Ore (g)
Special Screw Products Co., Ohio (a, b,f,g)
Spencer Nahm Co., Calif (a,b,f,g)
Spencer's Sons, I.S., Inc., Conn (a,b,g)
Standard Pressed Steel Co., Pa (a,b, c,e,f,g,h)
Standard Screw Products Co., Calif (a, b,g)
Star Heel Plate Co., Inc., NJ (g)
Steel Heddle Mfg. Co., Pa (a,b,c,e, f,g,h,j)
Steel Industries, Inc., Ind (a,b,g)
Steinen, William Mfg. Co., NJ (a,b, c,f,g,h)
Textile Shield Co., Inc., Mass (a,b,g)
Thompson-Bremer & Co., Ill (a,b,c,f, g,h)
Thompson Products, Inc., Ohio (h)
Titan Metal Mfg. Co., Pa (a,b)
Tompkins Products, Mich (a,b,c,d,f,g,j)
Trigon Specialties Corp., Ind (a,b,c, d,e,f,g,h,j)
Trim Alloys, Inc., Mass (a)
Ullmann, Inc., Wis (a,b,c,e,f,g,h)
Union Screw & Mfg. Co., Pa (a,b,g)
United Screw & Bolt Corp., Ill (a,b,g)
United Shoe Machinery Corp., Mass (a,b,c,f,g)
U.S. Steel Corp., Oil Well Supply Div., Tex (g)
Unity Machine & Tool Corp., Pa (a, g)
Vanamatic Co., Ohio (a,b,g)
Wagner Specialty Co., Wis (a,b,c,g,j)
Wall, P. Mfg. Co., Pa (a,b,c,g)
Walrod Machine Products, Ore (a,b,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Waterman Industries, Inc., Calif (a,b)
Weatherhead Co., Ind (a,b,c,d,e,f,g,h,j)
Weber-Knapp Co., NY (a)
Wedler Bros., Inc., Ohio (a,b,f,g)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (a,b,c,f,g)
Western Machine Co., Wis (a,b,c,f, g,j)
Wirth, Carl & Son, Inc., NY (a,b,c, d,e,f,g,h,j)
Worth Co., Wis (a,b,c,g)
Wright, Albert Screw Machine Products, Calif (a,b,f,g)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Zeller Corp., Ohio (g)

Selenium

American Metal Climax, Inc., NY
(aa)

American Nickel Alloy Mfg. Corp., NY (aa)
American Smelting & Refining Co., NY (q,aa)
Anaconda Aluminum Co., Sub. of Anaconda Co., NY (aa)

Belmont Smelting & Refining Works, Inc., NY
(aa)

Cerro de Pasco Sales Corp., NY
(aa)

Hardy, Charles, Inc., NY (aa)
Hommel, O. Co., Pa (aa)

Kawecki Chemical Co., NY (aa)
McGean Chemical Co., Ohio (aa)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Phelps Dodge Refining Corp., NY (aa)

Sheet

(see specific material)

Sheet Formed Plastics Parts

(see Moldings, Sheet)

Sherardized Coatings

(see Diffusion Coatings)

Silicides

(see Refractories)

Silicon

American Nickel Alloy Mfg. Corp., NY (w,aa)
Belmont Smelting & Refining Works, Inc., NY (aa)
du Pont de Nemours, E.I. & Co., Inc., Del (w)
Eagle-Picher Co., Ohio (aa)
Electro Metallurgical Co., Div. of Union Carbide Corp., NY (aa)
Foote Mineral Co., Pa (q)
Hardy, Charles, Inc., NY (aa)
Lavin, R. & Sons, Inc., Ill (w)
National Electric Products Corp., Pa (ff)
National-U.S. Radiator Corp., Plastic Metals Div., NY (aa)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w,bb,ee)
Utica General Jobbing Foundry, Inc., NY (aa)
Vanadium Corp. of America (w)

Silicon Bronze

(see Copper)

Silicone Plastics

Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics and Coal Chemicals Div., NY (p)
Alpha Wire Corp., NY (ee)
Bakelite Co., Div. of Union Carbide Corp., NY (p,y)
Belko Corp., Md (y)
Colonial Kolonite Co., Ill (bb,cc,ee)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Cordo Chemical Corp., Conn (y)
Dodge Fibers Corp., NY (s)
Dow Corning Corp., Mich (p,u,x,y)
Electrofilm, Inc., Calif (t)
Emerson & Cuming, Inc., Mass (u)
Flexible Tubing Corp., Conn (ee)
Formica Corp., Sub. of American Cyanamid Co., Ohio (cc,ee)
General Electric Co., Laminated Products Dept., Ohio (cc)
General Electric Co., Silicone Products Dept., NY (p,u,x,y)
General Gasket, Inc., Conn (cc)
Glass Reinforced Plastics Corp., Ohio (bb,ee)
Hall, C.P. Co., Ohio (p)
Hewitt-Robins, Inc., Conn (u,cc,ee)
Kurz Kasch, Inc., Ohio (y)
Maloney, F.H. Co., Tex (y)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Minneapolis Honeywell Regulator Co., Minn (u,x)
Narmco Resins & Coatings Co., Calif (x)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)
Panelyte Div., St. Regis Paper Co., NY (x,bb,cc,dd,ee)
Parker, Stearns & Co., Inc., NY (bb, cc,dd,ee)
Pawling Rubber Corp., NY (bb,dd,ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x)
Rogers Corp., Conn (u,y,bb,cc,dd)
Roth Rubber Co., Ill (cc)
Staver Co., Inc., NY (cc,dd)
Stockwell Rubber Co., Inc., Pa (y, bb,cc,dd)
Swedlow Plastics Co., Calif (cc)
Synthane Corp., Pa (cc,dd,ee)
Taylor Fibre Co., Pa (bb,cc,dd,ee)
Toyad Corp., Pa (u)
Union Carbide Corp., Silicones Div., NY (p,t,u,x,y)
U.S. Polymeric Chemicals, Inc., Conn (s)
Varflex Corp., NY (ee)
Western Felt Works, Ill (cc)

Silicone Rubber

Adhesive Products Corp., NY (x)
Alpha Wire Corp., NY (ee)
Armstrong Cork Co., Pa (bb,cc,dd)
Belko Corp., Md (y)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Colonial Rubber Co., Ohio (y)
Connecticut Hard Rubber Co., Conn (u,y,bb,cc,dd)—Ad p 205
Continental Rubber Works, Pa (bb, cc,dd,ee)
Continental-Diamond Fibre Corp., Del (cc,dd)
Dayton Rubber Co., Ohio (y,bb,cc,dd, ee)
Dodge Fibers Corp., NY (s)
Dow Corning Corp., Mich (p,u,x,y)
du Pont de Nemours, E.I. & Co., Inc., Del (cc)
Flexible Tubing Corp., Conn (ee)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
General Electric Co., Chemical & Metallurgical Div., Ill (cc,dd,ee)
General Electric Co., Silicone Products Dept., NY (p,u,y)—Ad p 251
Goshen Rubber Co., Inc., Ind (y)
Hewitt-Robins, Inc., Conn (cc,ee)
Insulation Mfrs. Corp., Ill (cc)
Maloney, F.H. Co., Tex (y)
Mechanical Rubber Products Co., NY (t,u,bb,cc,dd)
Micarta Div., Westinghouse Electric Corp., SC (cc)
Mid-States Rubber Products, Inc., Ind (y)
Minneapolis Honeywell Regulator Co., Minn (u,x)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
Parker-Hannifin Corp., Parker Seal Div., Ohio (u)
Pawling Rubber Corp., NY (bb,dd,ee)
Raybestos-Manhattan, Inc., NJ (bb, cc,dd)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x)
Rogers Corp., Conn (u,y,cc,dd)
Roth Rubber Co., Ill (cc)
Stockwell Rubber Co., Inc., Pa (u,y, bb,cc,dd)
Swedlow Plastics Co., Calif (cc)
Toyad Corp., Pa (u)
Union Carbide Corp., Silicones Div., NY (p,y,cc,dd)
U.S. Polymeric Chemicals, Inc., Conn (s)
U.S. Stoneware Co., NY (y)
Varflex Corp., NY (ee)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Williams-Bowman Rubber Co., Ill (y, bb,cc,dd,ee)

Silver and Its Alloys

Alloy Metal Powders, Inc., Iowa (aa)
Alpha Metals Inc., NJ (n,o,q,bb,cc,dd)
American Metal Climax, Inc., NY (w,aa)
American Platinum & Silver Div., Engelhard Industries, Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ff)
American Products Corp., Ill (dd,ff)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,o,q,bb,ee)
Anaconda Aluminum Co., Sub. of Anaconda Co., NY (o)
Baker & Co., Inc., NJ (n,o,v,w,z,aa, bb,cc,dd)
Belmont Smelting & Refining Works, Inc., NY (o,dd,ff)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (n,ff)
Bunker Hill Co., Sales & Fabrication Div., Calif (o)
Cerro de Pasco Sales Corp., NY (o,w)
Dahlin, C.A. Co., Ill (cc)
Designers Metal Corp., Ill (cc)
Eastern Smelting & Refining Corp., Mass (aa)
Federated Metals Div., American Smelting & Refining Co., NY (n)
Fox Products Co., Pa (n)
Fulton Gold Refiners Corp., NY (n,o, q,v,w,aa,bb,cc,dd)
General Plate Div., Metals & Controls Corp., Mass (n,v,w,z,aa,bb,cc,dd)
Goldsmith, S. & R. Bros., Co., Ill (n,o,v,w,z,aa,bb,cc,dd)
Handy & Harman, NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Hanovia Chemical & Mfg. Co., NJ (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Hommel, O. Co., Pa
Leach & Garner Co., Industrial Div., Mass (n,o,q,v,z,bb,cc,dd)
Lucas-Milhaupt Engineering Co., Wis (dd,ff)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (n,o,v,z,aa,bb,dd, ee,ff)
Metal Goods Corp., Tex (dd)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., NJ (aa)
Minimax Co., Ill (aa)
Nesor Alloy Products Co., NJ (dd,ff)
Ney, J.M. Co., Industrial Div., Conn (v,z,bb,cc,dd,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Peerless Roll Leaf Co., Inc., NJ (v,dd)
Reade Mfg. Co., Inc., NJ (aa)
Republic Metals Co., Inc., NY (o,w)
Rigidized Metals Corp., NY (cc,dd)
Rotometals, Calif (dd,ff)
Sel-Rex Corp., NJ (n,aa)—Ad p 285
Ullmann, Inc., Wis (o,ee)
United Wire & Supply Corp., RI (ff)
Vanadium-Alloys Steel Co., Pa (aa)
Western Gold & Platinum Co., Calif (n,bb,cc,dd,ff)
Wildberg Bros. Smelting & Refining Co., Calif (n,o,v,w,z,aa,bb,cc,dd,ff)
Williams Gold Refining Co., Inc., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)

Slush Moldings

(see Moldings)

Solders

A & A Die Casting Co., Calif
Abalon Precision Mfg. Corp., NY
All-State Welding Alloys Co., Inc., NY
American Emblem Co., Inc., NY
American Metal Climax, Inc., NY
American Products Corp., Ill
American Sheet Metal Works, Inc., Conn
American Smelting & Refining Co., NY
Anchor Metal Co., Inc., NY
Belmont Smelting & Refining Works, Inc., NY
Chemical Development Corp., Mass
Consolidated Fruit Jar Co., NJ
Division Lead Co., Ill
Empire Metal Co., NY
Eutectic Welding Alloys Corp., NY
Falstrom Co., NJ
General Findings & Supply Co., Industrial Div., Mass
Hayden Wire Works, Inc., Mass
Ideal Can Co., Mass
Indium Corp. of America, NY
Kenmore Machine Products, Inc., NY
Kester Solder Co., Ill
Kling Metal Spinning & Stamping Co., NY
Langsenkamp, F.H. Co., Ind
Lucas-Milhaupt Engineering Co., Wis
Lundquist Tool & Mfg. Co., Inc., Mass
Magnesium Co. of America, Ind
Magnesium Products of Milwaukee, Inc., Wis
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass
Metal Goods Corp., Mo
Metallizing Co. of Los Angeles, Inc., Calif
Midwest Stamping & Mfg. Co., Ohio
National Lead Co., NY
Ney, J.M. Co., Conn
Ren Plastics, Inc., Mich
Republic Metals Co., Inc., NY
Rotometals, Calif
Ruby Chemical Co., Ohio
United Wire & Supply Corp., RI
Waterman Industries, Inc., Calif
Wayne Chemical Products Co., Mich
West Haven Foundry Co., Conn
Whitehead Metal Products Co., Inc., NY
Wildberg Bros. Smelting & Refining Co., Calif
Williams Gold Refining Co., Inc., NY

Spinnings

Ace Metal Spinning, Ill (a,b,c,d,e,f, g,h,j)
Acme Metal Spinning, Inc., Minn (a b,c,d,e,f,g,h,j)
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a)
Aluminum Specialty Co., Wis (a)
Ampco Metal, Inc., Wis (b)

Letters in ( ) indicate materials and forms—turn page for key

Anchor Metal Spinning Co., Ohio (a, b,c,d,e,f,g,h,j)
Bartlett-Thompson Co. Inc., Mass (a, b,f,g)
Bergfels, William & Co., NJ (a,b,c, f,g,j)
Biersach & Niedermeyer Co., Wis (a,g)
Broadway Mfg. Co., Wis (a,b,c,g)
Brooks & Perkins, Inc., Mich (a,e,h)
Chase Brass & Copper Co., Conn (b)
Clover Industries, Inc., NY (a)
Commerical Shearing & Stamping Co., Ohio (a,b,e,f,g)
Craft Mfg. Co., Ill (a,b,c,d,f,g)
Cyril Bath Co., Ohio (a,g)
Dahlin, C.A. Co., Ill (a,b,d,e,f,g,h,j)
Dow Chemical Co., Mich (e)
Emerson-Sack-Warner Corp., Mass (a, b,c,e,f,g,h,j)
Garco Mfg. Co., Inc., Ill (a,b,e,f,g,h, j)
General Alloys Co., Mass (a,b,f,g)
Greene, G.G. Corp., Pa (a,g)
H & H Tube & Mfg. Co., Mich (b)
Hardy Mfg. Corp., Ind (a,g)
Kenmore Machine Products, Inc., NY (b)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Klinzing, A.F. Co., Inc., Wis (b)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Magline, Inc., Mich (e)
Magnesium Co. of America, Ind (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Manufacturers Service, Inc., Ohio (a, b,g)
Mirro Aluminum Co., Wis (a)
Morse, Fred W. Co., RI (a,b,c,g,j)
Muncie Metal Spinning, Inc., Ind (a, b,g)
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works, Inc., NJ (a,b,g)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g)
Perrin, Edward C. Co., NJ (a,b,g)
Phoenix Products Co., Wis (a,b,c,d,e, f,g,h,j)
Precision Metal Spinning Co., Mich (a,b,c,e,f,g)
Premier Metal Works, Inc., Ill (a,b,g)
Regal Ware, Inc., Wis (a,b,g)
Republic Steel Corp., Ohio (g)
Revere Copper & Brass, Inc., NY (b)
Reynolds Metals Co., Va (a)
Ryerson, Joseph T. & Son, Inc., Ill (g)
Searjeant Metal Products, Inc., NJ (a, g)
Seattle Boiler Works, Inc., Wash (a,g)
Smith-Victor Corp., Ind (a)
Solar Aircraft Co., Calif (g)
Spincraft, Inc., Wis (a,b,d,e,f,g,h,j)
Stainless Metals, Inc., NY (c,f,h)
Stirrup Metal Products Corp., NJ (a, b,g)
Teiner, Roland Co., Inc., Mass (a, b,c,e,f,g,h)
Toledo Stamping & Mfg. Co., Ohio (a,b,g,h)
Torngren, C.W. Co., Inc., Mass (a, b,c,e,f,g,h,j)
Ward, H.H. Co., Pa (a,b)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,e,f,g)

Sprayed Coatings

(see Metallized Coatings)

Stampings, Punchings

(see also Drawn, Pressed Parts)

A & A Die Casting Co., Calif (b)
Abalon Precision Mfg. Corp., NY (a, b,c,g)
Ackermann Mfg. Co., W.Va (g)
Acme Mfg. & Gasket Co., Pa (a,b, f,g)
Acme Metal Spinning, Inc., Minn (a, b,c,e,f,g,j)
Acme Stamping & Mfg. Co., Pa (a, b,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (a,g)
Acro Metal Stamping Co., Wis (a,b, f,g)
Adams, I.G. Metalware Co., Mo (a, b,c,e,f,g,j)
Advance Stamping Co., Mich (a,b,c, d,f,g,j)
Aerolite Electronics Corp., NJ (a,b, c,g)
Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (g)—Ad p 344
All-Form Metal Products Co., Ohio (a,b,c,d,e,f,g,j)
Allied Products Corp., Mich (a,g)
Alloy Products Corp., Wis (a,f,g,h)
Almco Steel Products Corp., Ind (a, b,g)
Alofs Mfg. Co., Mich (a,b,g)
Alox Mfg. Co., Mo (a,b,c,f,g)
Alpha Metals, Inc., NJ (a,g)
Aluminum Co. of America, Pa (a)
Aluminum Goods Mfg., Wis (a)
Aluminum Specialty Co., Wis (a)
American Brass Co., Conn (a,b,c,f,g,j)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Emblem Co., Inc., NY (a,b, g)
American Kitchens Div., Avco Mfg. Corp., Ind (g)
American Mfg. Co., Tenn (a,g)
American Sheet Metal Works, Inc., Conn (a,b,g)
American Stamping Co., Ohio (a,b,g)
Anchor Metal Spinning Co., Ohio (a, b,c,d,e,f,g,h,j)
Anderson, O.L. Co., Inc., Mich (a, b,c,e,f,g,h,j)
Anderson-Bolling Mfg. Co. Mich (a,g)
Anthes Force Oiler Co., Iowa (a,g)
Anti-Corrosive Metal Products Co., Inc., NY (g)
Armor Metal Products Co., Ohio (a,g)
Art Wire & Stamping Co., NJ (a,b,c,d,f,g)—Ad p 330
Arvin Industries, Inc., Ind (a,g)
Ashtabula Mfg. Co., Ohio (g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Atlas Metal Parts Co., Wis (a,b,c,g)
Auburn Mfg. Co., Conn (a,b,c,d,e,f,g)—Ad p 352
Auel Industries, Pa (a,b,f,g)
Auld, D.L. Co., Ohio (a,b,c)
Autel Electronics Co., Precision Machine & Welding Div., NJ (a,b,c,e, g,h)
Automotive Rubber Co., Inc., Mich (f,g)
Backus Novelty Co., Pa (a,b,c,f,g)
Barclay Mfg. Co., Ind (c)
Barium Steel Corp., NY (g)
Bartlett-Thompson Co., Inc., Mass (a, b,f,g)
Bay State Stamping Co., Mass (a,b,g)
Beacon Metal Mfg. Co., NY (a,b,c,d, e,f,g,h,j)
Behringer Metal Works, Inc., NJ (a, b,c,g)
Belmet Products, Inc., NY (a,b,g)
Benjamin Electric Mfg. Co., Ill (a, b,g)
Bennett Mfg. Co., NY (a,b,e,g)
Biersach & Niedermeyer Co., Wis (a, b,c,g)
Bingham Herbrand Corp., Bingham Stamping Div., Ohio (g)
Blacher Bros., Inc., RI (a,b,g)
Blaco Mfg. Co., Ohio (b,g)
Blickman, S., Inc., NJ (a,b,c,g)
Boots Aircraft Nut Corp., Conn (g)
Borg-Warner Corp., Ingersoll Products Div., Ill (g)
Brandt, Charles T., Inc., Md (a,b,e, f,g)
Brewer-Titchener Corp., NY (a,g)
Brooks & Perkins, Inc., Mich (a,e,h)
Budek & Bock Spring Mfg. Co., Ill (a,g)
Burgess-Norton Mfg. Co., Ill (c)
Campbell, A.S. Co., Inc., Mass (a,g)
Carbo Tool & Die Co., Ohio (c)
Carroll Pressed Metal, Inc., Mass (a, b,f,g)
Cartwright, R. Tube Products Co., Mich (a,b,g)
Chase Brass & Copper Co., Conn (b)
Cincinnati Pump & Mfg. Co., Inc., Ohio (g)
Clendenin Bros., Inc., Md (a,b)
Cleveland Metal Products Co., Ohio (a,b,c,f,g)
Cleveland Pressed Products Corp., Ohio (a,b,g)
Clover Industries, Inc., NY (a)
Cly-Del Mfg. Co., Inc., Conn (a,b, f,g,j)
Columbia Metal Stamping Co., Ohio (a,g)
Columbian Steel Tank Co., Mo (g)
Columbus Dental Mfg. Co., Ohio (a, b,c,g)
Columbus Jack Corp., Ohio (a,c,g)
Comerford Mfg. Co., Inc., Conn (a, b,c,e,f,g,j)
Commercial Shearing & Stamping Co., Ohio (a,b,f,g)
Consolidated Fruit Jar Co., NJ (a, b,c,d,g,j)
Cooley, W.J. & Co., Tenn (a,b,g)
Craft Mfg. Co., Ill (a,b,c,d,f,g)
Croname Inc., Ill (a,b,g)
Crown Metal Co., Wis (d)
Cuyahoga Stamping Co., Ohio (a,b,g)
Cyril Bath Co., Ohio (a,e,f,g,h)
Dahlin, C.A. Co., Ill (a,b,d,e,f,g,j)
Danby Mfg. Co., Mich (a,b,g)
Dare Products, Inc., Mich (g)
Day Co., Minn (a,g)
Dayton Rogers Mfg. Co., Minn (a,b,g)
Dearborn Stamping Co., Mich (g)
Defiance Metal Products Co., Ohio (a,g)
Defiance Stamping Co., Ohio (g)
Detroit Stamping Co., Mich (a,b,g)
Dirilyte Co. of America, Inc., Ind (a,b)
Dolin Metal Products, Inc., NY (g)
Dow Chemical Co., Magnesium Div., Mich (e)
Duplex Mfg. Corp., NY (a,g)
Duplican Co., Inc., Mass (a,b,c,e,f, g,h,j)
Earley, Sam C. Corp., Ohio (a,b,g)
Eastern Tool & Mfg. Co., NJ (a,b,c, g)
Electric Auto-Lite Co., Ohio (a,b,g)
Electric Materials Co., Pa (b)
Electronic Parts Mfg. Co., NJ (c,f,g)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a, b,c,f,g)
Empire Spring Co., Ohio (a,b,g)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (g)
Enamel Products Co., Ohio (a,c)
Etched Products Corp., NY (a,b,g)
Eureka Electric Products Co., Pa (a,b)
Everard Tap & Die Corp., NY (a, b,f,g)
Fabristeel Products, Inc., Mich (g)
Falstrom Co., NJ (a,b,e,g)
Farwell Metal Fabricating, Minn (a, b,e,g)
Federal Tool Corp., Ill (a,b,c,g)
Federal Tool & Mfg. Co., Minn (a, b,c,f,g)
Figley Die & Stamping Co., Ohio (a, b,g)
FitzSimons Mfg. Co., Mich (a,b,g)
Fletcher Enamel Co., W.Va (a,b,c,d, e,f,g)
Follansbee Steel Corp., Sheet Metal Specialty Div., W.Va (a,b,g)
Forg, Peter Mfg. Co., Mass (a,b,c,g)
Fox Co., Ohio (a,b,c,g)
Fox Products Co., Pa (c)
Fryling Mfg. Co., Pa (a,b,f,g,j)
Garco Mfg. Co., Inc., Ill (a,b,c,e,f, g,h,j)
Gary Steel Products Corp., Va (a,g)
General Alloys Co., Mass (a,b,f,g)
General Extrusions, Inc., Ohio (a)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
General Gasket, Inc., Conn (a,b,c,d,g)
Geometric Stamping Co., Ohio (a,b,g)
Gerstenslage Co., Ohio (a,g)
Geuder, Paeschke & Frey Co., Wis (a, c,f,g)
Giant Grip Mfg. Co., Wis (a,c,e,f,g,h)
Grammes, L.F. & Sons, Inc., Pa (a,b, g)
Grand Haven Stamped Products Co., Mich (a,b,g,j)
Grand Sheet Metal Products Co., Consumer Products Div., Ill (a,b,c,e,f, g,h,j)
Greene, G.G. Corp., Pa (a,b,e,f,g,j)
Greene Mfg. Co., Wis (a,g)
Guarantee Specialty Mfg. Co., Ohio (a,b,c,g,j)
H.K. Metal Craft Mfg. Corp., NY (a, b,c,g,j)
H P L Mfg. Co., Ohio (a,b,g)—Ad p 350
Haigh Mfg. Co., Mich (a,b,f)
Hardy Mfg. Corp., Ind (a,b,g)
Headly Mfg. Co., Ill (a,b,c,e,f,g,h,j)
Heypian Mfg. Co., NJ (a,b,f,g)
Hoofer Mfg. Co., Ill (a,g)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Hunter Spring Co., Pa (b,g)
Ideal Can Co., Mass (a,b,c,g)
Indium Corp. of America, NY (d)
Indus Corp., Ind (g)
Industrial Precision Products, Ill (a, b,c,e,f,g,h,j)
Ingram-Richardson, Inc., Ind (g)
Inshield Die & Stamping Co., Ohio (a,b,g)
Instrument Specialties Co., Inc., NJ (b)—Ad p 343
Interlake Mfg. Co., Mich (a,g)
Irvington Form & Tank Corp., NY (a, b,g)
Irwin Foundry and Mine Car Co., Pa (g)
Jackson Auto Radiator, Ill (a,b,g)
Jarco Metal Products, NY (a,b,g,j)
Judd Industries, Inc., Ohio (a,b,g)
K-D Mfg. Co., Tex (g)
Kaiser Steel Corp., Calif (g)
Kees, F.D. Mfg. Co., Neb (a,b,g)
Kelley Mfg. Co., Tex (a,b,g)
Kenmore Machine Products, Inc., NY (b)
Kickhaefer Mfg. Co., Wis (a,b,g)
King Laboratories, Inc., NY (a,b,c, f,g)
Kirchhof Patent Co., Inc., NY (a,b, c,f,g,j)
Kling Metal Spinning & Stamping Co., NY (a,b,c,d,e,f,g,j)
Koehler Mfg. Co., Mass (a,b,c,d,g)
Krueger & Hudepohl, Inc., Ohio (a, b,c,f,g)
Laminated Shim Co., Conn (a,b,g)—Ad pp 340-41
Larkin Specialty Mfg. Co., Calif (a,b, g)
Larson Tool & Stamping Co., Mass (a, b,c,e,f,g,h,j)
Laystrom Mfg. Co., Ill (a,b,c,f,g,j)
Leake Engineering Co., Mich (a,b,c, d,e,f,g,h,j)
Linden & Co., Inc., RI (a,b,g)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Lundquist Tool & Mfg. Co., Inc., Mass (a,b,c,e,f,g,h)
Lynn, Gary Co., Ohio (a,b,g)
Machine Products Corp., Ohio (a,b,d,f, g)

Magline, Inc., Mich (e)
Magnesium Co. of America, Ill (a,e)
Magnesium Products of Milwaukee, Inc., Wis (a,e)
Magnetic Stamping Co., Pa (a,b,g)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (b)
Maloney, F.H. Co., Tex (g)
Manganese Steel Forge Co., Pa (g)
Manufacturers Service, Inc., Ohio (a,b,g)
Mayville Metal Products Co., Wis (a,b,g)
McDowell Mfg. Co., Pa (a,b,g)
McKinney Mfg. Co., Pa (a,b,e,f,g)
McLanahan & Stone Corp., Pa (c,g)
Melco Wire Products, Calif (a)
Melray Mfg. Co., Ill (a,b,c,d,e,f,g,h,j)
Metal Forming Corp., Ind (a,b,c,e,f,g,h,j)
Metal Parts & Stamping Co., Ohio (a,b,c,f,g,h,j)
Metallurgical Products Co., Pa (a,b,f,h,j)
Micacraft Products, Inc., NJ (a)
Midwest Stamping & Mfg. Co., Ohio (a,b,f,g)
Milwaukee Stamping Co., Wis (a,b,g)
Mirro Aluminum Co., Wis (a)
Misner Corp., Neb (a,b,c,g)
Monarch Tool & Mfg. Co., Ky (a,b,c,g)
Morrison Steel Products, Inc., NY (g)
Morse, Fred W. Co., RI (a,b,c,g,j)
Mueller Machine Products, Inc., Wis (a,b,c,d,f,g)
National Gasket & Washer Mfg. Co., Inc., NY (a,b,c,d,e,f,g,h,j)
National Lead Co., NY (a,c,h)
National Metal Products Co., Pa (a,c,g)
National Supply Co., Pa (g)
Newark Wire Cloth Co., NJ (a,b,c,d,f,g)
Nichols, L.O. & Son Mfg. Co., Mo (a,b,c,g)
Nigg Engineering Corp., Calif (a,b,c,g)
Noera Mfg. Co., Conn (a,b,g)
Norcross, C.S. & Sons Co., Ill (g)
Ohio Nut & Washer Co., Ohio (a,g)
Ormond Mfg., Co., Inc., NJ (a,b,f,j)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g)
Paragon Spring Co., Ill (a,b,c,f,g)
Parish Pressed Steel Div., Dana Corp., Pa (a,g)
Parker, Charles Co., Conn (a,f)
Parker Metal Goods Co., Mass (a,b,g)
Peck Spring Co., Conn (a,b,c,f,g,h)
Peerless Products Industries, Ill (a,b,g)
Pemco Wheel Co., Mich (g)
Penn Fibre & Specialty Co., Inc., Pa (a,b,c,d,e,f,g,j)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (a,b,g)
Peterson Products Corp., Ill (a,b,f,g)
Phoenix Iron & Steel Co., Pa (a,g)
Pierce Governor of Ohio, Inc., Ohio (a,g)
Pioneer Stamped Products Co., NY (a,b,c,d,e,f,g,h)
Pittsburgh Forgings Co., Mich (g)
Porter, H.K., Inc., Forge & Fittings Div., Ohio (a,g)
Powell Pressed Steel Co., Ohio (a,g)
Premier Metal Works, Inc., Ill (a,b,f,g)
Pressed Steel Co., Pa (a,b,f,g)
Presswork, Inc., Mich (a,b,d,g)
Queen Products Co., Inc., Ky (a,b,g)
Reed & Prince Mfg. Co., Mass (a,b,c,g)
Regal Ware, Inc., Wis (a,b,g)
Reliable Spring & Wire Forms Co., Ohio (a,b,f,g)

Republic Steel Corp., Ohio (g)

Revere Copper & Brass, Inc., NY (a,b,c,f,g,j)
Rex Corp., Mass (a,g)
Reynolds Metals Co., Va (a)
Rochester Novelty Works, Inc., NY (a,g)

Rockwell - Standard Corp., Stamping Div., NY (a,b,c,d,e,f,g,h,j)—Ad p 348

Rolock, Inc., Conn (f)
Roth Steel Products Co., Ohio (g)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
St. Marys Carbon Co., Pa (b)
Salem Tool Co., Ohio (g)
Sargent & Greenleaf, Inc., NY (a,b,g)

Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)

Searjeant Metal Products, Inc., NJ (g)
Security Sash & Screen Co., Mich (a)
Servwell Products Co., Ohio (b,g)
Shakeproof Div., Illinois Tool Works, Ill (b,g)
Shank Metal Products Co., NY (a,g)
Sheet Metal Mfg. Co., Ohio (a,g)
Shelby Mfg. Co., Ohio (g)
Sheller Mfg. Corp., Mich (g)
Simonsen Metal Products Co., Ill (a,g)
Sinclair Co., Mass (b,g)
Sioux City Foundry & Boiler Co., Iowa (g)
Smithers Tool & Machine Products, Inc., NY (g)
Smith-Victor Corp., Ind (a,g)
Smoot-Holman Co., Calif (g)
Sommer Metalcraft Corp., Ind (a,g)
South River Metal Products Co., Inc., NJ (a,e,g)
Southern Car & Mfg. Co., Inc., Ala (a,b,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,b,g)
Stainless Metals, Inc., NY (c,f,h)
Stamford Metal Specialty Co., Inc., NY (a,f,g)
Standard Forge & Axle Co., Inc., Ala (g)
Standard Nut & Bolt Co., RI (a,b,f,g)
Standard Steel Sections, Inc., NY (a,b,c,g)
Stanley Industrial Sales, Stanley Works, Conn (g)
Star Stamping Co., Mich (a,b,g)
Staver Co., Inc., NY (a,b,c,d,e,f,g,h,j)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f,g,h,j)
Steel Industries, Inc., Ind (a,b,g)
Steinen, William Mfg. Co., NJ (a,b,c,g)
Stenman, Bror F., Mass (a,g)
Stimpson, Edwin B. Co., Inc., NY (a,b,f,g,j)
Stirrup Metal Products Corp., NJ (a,b,c,g)
Superior Spinning & Stamping Co., Ohio (a,b,f,g)

Sylvania Electric Products, Inc., Pa (a,b,c,f,g)

Textile Shield Co., Inc., Mass (a,b,g)
Thompson Products, Inc., Ohio (g)
Thompson-Bremer & Co., Ill (a,b,c,f,g,h)
Toledo Stamping & Mfg. Co., Ohio (a,b,g,h)
Transue & Williams Steel Forging Corp., Ohio (f,g)
Triangle Stamping Co., Ohio (a,b,c,d,f,g,j)
Turner & Seymour Mfg. Co., Conn (a,b,g)
United Metal Products Corp., Mich (a,b,c,g)
United Screw & Bolt Corp., Ill (a,b,g)
United Shoe Machinery Corp., Mass (a,b,f,g,j)
U.S. Gasket & Shim Co., Ohio (a,b,c,d,e,f,g,h,j)
United-Carr Fastener Corp., Mass (a,b,g)
Unity Machine & Tool Corp., Pa (a,b,g)
Van Valkenburg, L.A. Co., Mass (a,b,c,f,g)
Variety Stamping Corp., Ohio (a,b,c,g)
WLS Stamping Co., Ohio (a,b,c,d,e,f,g,h,j)
Wabash Metal Products Co., Inc., Ind (a,b,g)
Wagner, E.P. Mfg. Co., Wis (a,b,c,g,j)
Wagner Specialty Co., Wis (a,b,c,g,j)
Wall, P. Mfg. Co., Pa (a,b,g)
Wall Tube & Metal Products Co., Tenn (g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Waterbury Buckle Co., Conn (a,g,j)

Waterbury Cos., Inc., Conn (a,b,g)

Waterbury Pressed Metal Co., Conn (a,b,f,g)
Waterman Industrial, Inc., Calif (a,b,g)
Wayne Foundry & Stamping Co., Mich (a,b,e,g,h)
Weatherhead Co., Ind (a,b,g,h)
Weber-Knapp Co., NY (a,g)
Welding Apparatus Co., Ill (a,f,g)
Wesbar Stamping Corp., Wis (a,g)
Wesco Spring Co., Ill (g)
Western Tool & Die Works, Ore (a,b,g)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (f)
Wilder Mfg. Co., Inc., Calif (a,c,g)
Williams, F.B. Co., Ill (g)
Williams, H.E. Products Co., Mo (a,b,c,g,j)
Wirth, Carl & Son, Inc., NY (a,b,c,g)
Wisconsin Gasket & Mfg. Co., Wis (a,b,g)
Wisconsin Tool & Stamping Co., Ill (a,b,d,f,g,j)
Wood, John Co., Minn (g)
Woolf Aircraft Products, Inc., Mich (a,b,g)
Worcester Pressed Steel Co., Mass (a,b,c,e,f,g,h,j)
Worcester Stamped Metal Co., Mass (a,b,e,f,g,h,j)
Worth Co., Wis (a,b,c,g)
Wuest Bros., Inc., Ky (a,b,c,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Mfg., Inc., Ohio (a,g)
Youngstown Sheet and Tube Co., Ohio (g)

Steatite

(see Ceramics)

Steel, Carbon

Acme Tube, Inc., NJ (ee)
Acme-Newport Steel Co., Ky (w,z,cc)
Advance Screw Products Co., Inc., Wis (o)
Advance Stamping Co., Mich (dd)

Ainsworth-Precision Castings Co., Div. of Harsco Corp., Mich (ee)

Alan Wood Steel Co., Pa (o,q,w,z,cc,dd)
Albert Wright Screw Machine Products, Calif (bb)
Alco Products, Inc., NY (q,aa)

Allegheny Ludlum Steel Corp., Pa (dd)

Alloy Metal Powders, Inc., Iowa (aa)
Almco Steel Products Corp., Ind (o,z,bb,cc,dd)
Amalgamated Steel Corp., Ohio (o,bb)

American Cast Iron Pipe Co., Ala (ee)—Ad p 329

American Metal Products, Inc., Ohio (z,cc)
American Sheet Metal Works, Inc., Conn (bb,cc,ee,ff)
American Silver Co., NY (v,dd)
American Steel & Wire Div., U.S. Steel Corp., Ohio (o,bb,dd,ff)
Ames, W. & Co., NJ (o)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb,ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q,w)
Armco Steel Corp., Ohio (o,z,bb,cc,dd,ff)
Armco Steel Corp., Sheffield Div., Mo (o,q,w,z,bb,cc,dd,ff)
Athenia Steel Div., National Standard Co., NJ (dd)
Atlantic Steel Co., Ga (o,q,w,z,bb,cc,dd,ee,ff)
Austenal, Inc., NY (w)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Barium Steel Corp., NY (q,w,z,ee)
Baxter Foundry & Machine Works, Inc., Id (o,z,bb,cc,dd)
Bethlehem Steel Co., Pa (o,q,z,bb,cc,dd,ee,ff)
Biddle Screw Products Co., Ind (bb,ee)
Bliss & Laughlin, Inc., Ill (o)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Brainard Steel Div., Sharon Steel Corp., Ohio (ee)
Budek & Bock Spring Mfg. Co., Ill (dd,ff)
Burkhardt Steel Co., Colo (o,z,cc,dd, ee)
Byers, A.M. Co., Pa (o,q,w,z,cc)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd, ff)
Caspers Tin Plate Co., Ill (cc,dd)
Castle, A.M. & Co., Ill (o,z,bb,cc, dd,ee,ff)
Central Fabricators, Inc., Ohio (z, bb,cc,ee)
Chicago Steel Service Co., Ill (o,z, bb,cc,dd)
Cincinnati Pump & Mfg. Co., Inc., Ohio (ff)
Clad-Rex Corp., Ill (cc)
Clark Perforating Co., Mich (cc,dd)
Clayton Mark & Co., Ill (ee)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Connors Steel Div., H.K. Porter Co., Inc., Ala (o,q,w,dd)
Continental Steel Corp., Ind (o,q,bb,ff)
Crucible Steel Co. of America, Pa (o, q,w,z,bb,cc,dd,ee,ff)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Cumberland Steel Co., Md (o)
Dahlin, C.A. Co., Ill (z,cc,dd,ee)
Designers Metal Corp., Ill (cc)
Detroit Steel Corp., Portsmouth Div., Mich (q,w,bb,cc)
Dixon Sintaloy, Inc., Conn (o)
Eaton Mfg. Co., Reliance Div., Ohio (o,ff)

Edgcomb Steel & Aluminum Corp., NJ
(o,z,cc,dd)—Ad p 70
Elliott Bros. Steel Co., Pa (cc,dd)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (z,cc)
Enterprise Wheel & Car Corp., Va (o, z,cc)
Follansbee Steel Corp., W.Va (cc,dd)
Forg, Peter Mfg. Co., Mass (cc)
Fort Howard Steel & Wire Co., Wis (o)
Franklin Steel Div., Borg-Warner Corp., Pa (o)

Frasse, Peter A. & Co., Inc., NY
(o,bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (ee)
Gary Steel Products Corp., Va (o,z,cc)
General Motors Corp., Rochester Products Div., NY (ee)
Granite City Steel Co., Ill (w,z,cc)
Great Lakes Steel Corp., Div. of National Steel Corp., Mich (z,cc,dd)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o, bb,ee,ff)
Inland Steel Co., Ill (o,z,cc,dd)
Inshield Die & Stamping Co., Ohio (cc)
Isaacson Iron Works, Wash (q,w)
Jackson Steel Products, Inc., NY (ee)
Jones & Laughlin Steel Corp., Pa (o, q,z,bb,cc,dd,ee,ff)
Jones & Laughlin Steel Corp., Strip Steel Div., Ohio (dd)
K-D Mfg. Co., Tex (o)
Kaiser Steel Corp., Calif (n,o,q,w, z,bb,cc,dd,ee)
Keystone Drawn Steel Co., Pa (o)
Keystone Steel & Wire Co., Ill (w, bb)
Kinkead Industries, Inc., Ill (o,z,bb, cc,dd)
Korhumel Steel and Aluminum Co., Ill (o,z,bb,cc,dd,ff)
Laclede Steel Co., Mo (o,q,w,bb,dd, ee,ff)
Larson, Charles E. & Sons, Inc., Ill (o)
La Salle Steel Co., Ill (o)
Levinson Steel Co., Pa (o,z,bb,cc,dd)
Lock Joint Tube Co., Inc., Ind (ee)
Lockport Mfg. Co., Ill (z)

Lukens Steel Co., Pa
(w,z)—Ad pp 66-67
Lundquist Tool & Mfg. Co., Inc., Mass (bb,cc,dd,ee,ff)
Luria Engineering Co., Pa (z,bb,cc)
Mahon, R.C. Co., Mich (o,z,cc,dd)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (o,dd,ee)

Mallory-Sharon Metals Corp., Ohio
(cc)
McCarter Iron Works, Inc., Pa (o,z,bb, cc)
McGregor-Michigan Corp., Mich (z)
McInnes Steel Co., Pa (o)
McLouth Steel Corp., Mich (cc,dd)
Mechanical Steel Tubing Corp., NY (ee)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Modern Plating Corp., Ill (z)
Morrisville Foundry Co., Inc., Vt (bb, cc,dd)
Murray, A.B. Co., Inc., NJ (ee)
Narragansett Boiler Works, Inc., RI (o,z,bb,cc,ee)
National Galvanizing Co., Pa (z,bb, cc,ee)
National Lock Washer Co., NJ (ff)
National Supply Co., Industrial Products Div., Calif (o,q,w)
National Tube Div., U.S. Steel Corp., Pa (ee)
National U.S. Radiator Corp., Plastic Metals Div., Pa (aa)
National-Standard Co., Mich (dd,ff)
Nesor Alloy Products Co., NJ (ff)
New York Iron Roofing & Corrugating Co., Inc., NJ (cc)
Newman-Crosby Steel Co., RI (dd)
Nikoh Tube Co., Ill (bb,cc,dd,ee)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Northwestern Steel & Wire Co., Ill (o,q,w,z,bb,ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Ormond Mfg. Co., Inc., NJ (cc,dd,ff)
Pacific States Steel Corp., Calif (o, q,w)
Pacific Tube Co., Calif (o)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Peninsular Steel Co., Mich (o,z)
Phoenix Iron & Steel Co., Pa (z)
Pittsburgh Forgings Co., Mich (o,q)
Pittsburgh Steel Co., Pa (q,w,bb,cc, dd,ee,ff)
Precision Tube Co., Inc., Pa (ee)
Rathbone Corp., Mass (o,bb)

Republic Steel Corp., Ohio
(o,q,w,z,bb,cc,dd,ee,ff)
Reynolds Aluminum Supply Co., Ga (z)
Rigidized Metals Corp., NY (cc,dd)
Roebling's, John A. Sons Corp., NJ (bb,dd,ff)
Rome Strip Steel Co., Inc., NY (o, z,dd,ff)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
St. Louis Steel Casting, Inc., Mo (o)

Sandusky Foundry & Machine Co., Ohio
(ee)

Sandvik Steel, Inc., NJ
(dd)—Ad p 68
Saran Lined Pipe Co., Mich (ee)
Sawhill Tubular Products, Inc., Pa (ee)
Scudder, E.J. Foundry & Machine Co., NJ (bb,ee)
Service Steel Div., Van Pelt Corp., Mich (ee)
Sharon Steel Corp., Pa (q,w,z,cc,dd, ee)
Sharpsville Steel Fabricators, Inc., Pa (o,z,bb,cc)
Shaw-Kendall Engineering Co., Ohio (ee)
Simonds Saw & Steel Co., Mass (o,cc)
Smith-Moon Steel Co., Inc., Kan (o, z,cc)
Sonken-Galamba Corp., Kan (z,bb,cc, ee)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (o,z, bb,cc,dd,ee,ff)
Sun Steel Co., Ill (o,z,bb,cc,dd)
Superior Drawn Steel Co., Pa (o,bb,ff)
Superior Steel Div., Copperweld Steel Co., Pa (dd)
Superior Tube Co., Pa (ee)
Sweet's Steel Co., Va (o)

Sylvania Electric Products, Inc., Parts Div., Pa
(ff)—Ad p 249

Thomas Strip Div., Pittsburgh Steel Co., Pa
(dd)—Ad pp 74-5
Thompson Industries, Inc., NY (bb)
Thompson Wire Co., Mass (dd)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (ee)
Topeka Foundry & Iron Works Co., Inc., Kan (o,z,bb,cc,dd)
Trojan Steel Co., W.Va (o,z,bb,cc,dd)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Udylite Corp., Mich (n)
Union Iron Works, Wash (o,z,cc,dd,ee)
Union Steel Corp., NJ (dd)
United Screw & Bolt Corp., Ill (bb, cc,dd,ff)
U.S. Challenge & Challenge Co., Ill (bb)
U.S. Gasket & Shim Co., Ohio (cc,dd)

U.S. Steel Corp., Pa
(o,q,w,z,bb,cc,dd,ff)—Ad p 77
Vanadium-Alloys Steel Co., Pa (o,q, w,z,aa,bb,cc,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (o,q,w,bb,ff)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., Ill (ee)
Wal-Mar Corp., Ill (ee)
Washburn Wire Co., Phillipsdale Div., RI (q,bb,dd)

Weirton Steel Co., Div. of National Steel Corp., W.Va
(z,cc,dd)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (o)
Western Iron & Foundry Co., Inc., Kan (o,z,bb,cc,dd)
Wheatland Tube Co., Pa (ee)
Wickwire Bros., Inc., NY (bb,ff)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (w,z)
Wilson Steel & Wire Co., Ill (ff)
Wyckoff Steel Co., Pa (o,z)
Youngstown Sheet and Tube Co., Ohio (o,z,bb,cc,dd,ee,ff)

Steel, Carbon—Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Foundries & Steel, Inc., NY
Allied Steel Castings Co., Ill
All-Metals Precision Casting Corp., NY
Alloy Cast Steel Co., Ohio
Alloy Precision Castings Co., Ohio
Alloy Steel & Metals Co., Calif

American Cast Iron Pipe Co., Ala
American Steel Foundries, Ill
Arneson Foundry Co., Wis
Arwood Precision Castings Corp., NY
Atlantic Foundry Co., Ohio
Atlantic Steel Castings Co., Pa
Austenal, Inc., NY
Auto Specialties Mfg. Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Birdsboro Steel Foundry & Machine Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Calumet Steel Castings Corp., Ind
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Commercial Steel Casting Co., Ohio
Continental Foundry & Machine Co., Ind
Crucible Steel Casting Co., Pa
Crucible Steel Co. of America, Pa
Dayton Steel Foundry Co., Ohio
Eastern Malleable Iron Co., Del
Electric Steel Castings Co., Ind
Electric Steel Foundry Co., Ore
Electrocast Steel Foundry Co., Ill
Empire Foundry Co., Inc., Calif
Empire Steel Castings, Inc., Pa
Falk Corp., Wis
Farrel-Birmingham Co., Inc., Conn
Federal Steel Products Corp., Tex
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa
General Electric Co., Foundry Dept., NY
Glover Machine Works, Ga
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Hughes Tool Co., Tex
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Kay-Brunner Steel Products, Inc., Calif
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Lectromelt Casting Div., Akron Standard Mold Co., Ohio
Liberty Foundry Co., Mo
Lincoln Iron Works, Vt
Los Angeles Steel Casting Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Manco Products, Inc., Mich
Massillon Steel Casting Co., Ohio
Mercast Mfg. Corp., Calif
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Casting Co., Minn
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
Monroe Steel Castings Co., Mich
Montague Machine Co., Mass
National Iron Co., Minn
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla
Olympic Steel Works, Wash
Omaha Steel Works, Neb
Pelton Steel Casting Co., Wis
Penn Steel Castings Co., Pa
Perfecto Cast, Calif
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Posey Iron Works, Inc., Pa
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Quincy Steel Casting Co., Mass
Racine Steel Castings Co., Wis
Reliance Steel Castings Co., Pa
Ross-Meehan Foundries, Tenn
St. Louis Steel Casting, Inc., Mo

Sandusky Foundry & Machine Co., Ohio
Sawbrook Steel Castings Co., Ohio
Scullin Steel Co., Mo
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Skookum Co., Inc., Ore

Sorbo-Mat Process Engineers, Mo
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Strong Steel Foundry Co., NY
Superior Foundry, Inc., Ohio
Superior Steel & Malleable Castings Co., Mich
Swedish Crucible Steel Co., Mich
Texas Foundries, Inc., Tex
Texas Steel Co., Tex
Thys Co., Calif
Union Iron Works, Wash
Union Spring & Mfg. Co., Pa
Unitcast Corp., Ohio
—Ad p 330
U.S. Pipe & Foundry Co., Ala
Utility Steel Foundry, Calif
Valley Steel Casting Co., Mich
Vulcan Iron Works, Pa
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Pa
Westlectric Castings, Inc., Calif
Worthington Corp., NJ

Steel, Heat and Corrosion Resistant

Acme Tube, Inc., NJ (ee)
Advance Stamping Co., Mich (dd)
Alco Products, Inc., NY (q)
Allegheny Ludlum Steel Corp., Pa
(o,q,w,z,bb,cc,dd,ee,ff)
Alloy Metal Powders, Inc., NY (aa)
Alloy Metal Products, Inc., Iowa (o,q,w)
Alofs Mfg. Co., Mich (dd)
American Cast Iron Pipe Co., Ala
(ee)—Ad p 329
American Sheet Metal Works, Inc., Conn (bb,cc,ee,ff)
American Silver Co., NY (v,dd)
American Steel & Wire Div., U.S. Steel Corp., Ohio (dd,ff)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb,ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q)
Armco Steel Corp., Ohio (o,q,v,z,bb,cc,dd,ff)
Athenia Steel Div., National-Standard Co., NJ (dd)
Austenal, Inc., NY (w)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Bethlehem Steel Co., Pa (o,q,z,bb,cc,dd,ee,ff)
Biddle Screw Products Co., Ind (bb)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa
(ee,ff)—Ad p 324
Bridgeport Brass Co., Conn (bb)
Brinkerhoff Brass & Bronze Works, Inc., NY (z,bb,cc)
Byers, A.M. Co., Pa (o,q,w,z,cc)
Cannon-Muskegon Corp., Mich (w)
Carlson, G.O., Inc., Pa (o,z,cc)
Carpenter Steel Co., Pa (o,q,w,bb,dd,ff)
Carpenter Steel Co., Alloy Tube Div., NJ (ff)
Castle, A.M. & Co., Ill (o,q,z,cc,dd,ff)
Central Fabricators, Inc., Ohio (z,bb,cc,ee)
Chromalloy Corp., NY
(cc)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Crucible Steel Co. of America, Pa (o,q,w,z,bb,cc,dd,ee,ff)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Curtiss-Wright Corp., Metals Processing Div., NY
(ee)
Damascus Tube Co., Pa
(ee)—Ad p 351
Dixon Sintaloy, Inc., Conn (o)
Driver, Wilbur B. Co., NJ
(v,bb,dd,ff)—Ad p 131
Eastern Stainless Steel Corp., Md (z,cc)
Eaton Mfg. Co., Reliance Div., Ohio (o,ff)
Edgcomb Steel & Aluminum Corp., NJ
(o,z,cc,dd)
Electric Steel Foundry Co., Ore (o,q,w,z,bb,cc,dd,ee,ff)
Erskine Precision Wire Corp., Pa (ff)
Firth Sterling, Inc., Pa (o,q,bb,dd)
Frasse, Peter A. & Co., Inc., NY
(o,bb,cc,dd,ee,ff)
Fromson Orban Co., Inc., NY (ee)
Gary Steel Products Corp., Va (o,z,cc)
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd,ff)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o,z,bb,dd,ee,ff)
Hexcel Products, Inc., Calif (v)
Hoeganaes Sponge Iron Corp., NJ (aa)
Industrial Stainless Steels, Inc., Mass (o,q,z,bb,cc,dd,ee,ff)
Johnson, A. & Co., Inc., NY (ee)
Jones & Laughlin Steel Corp., Pa (o,q,cc,dd)
Jones & Laughlin Steel Corp., Stainless Steel Div., Mich
(o,q,w,bb,cc,dd,ff)—Ad p 73
Joslyn Stainless Steels, Ill (o,q,w,bb,ff)
Kaiser Steel Corp., Calif (o,q,w,z,bb,cc,dd)
Kinkead Industries, Inc., Ill (cc,dd)
Kolcast Industries Div., Thompson Products, Inc., Ohio (q,w)
Krueger Fabricating Co., Inc., Wis (cc)
Larson, Charles E. & Sons Inc., Ill (o)
Latrobe Steel Co., Pa (o,q,w)
Lockport Mfg. Co., Ill (z)
Lukens Steel Co., Pa
(w,z)—Ad pp 66-67
Lundquist Tool & Mfg. Co., Inc., Mass (bb,cc,dd,ee,ff)
Makepeace, D.E. Div., Engelhard Industries Inc., Mass (o,dd,ee)
McCarter Iron Works, Inc., Pa (o,z,bb,cc)
McInnes Steel Co., Pa (o)
Mechanical Steel Tubing Corp., NY (ee)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Morrisville Foundry Co., Inc., Vt (bb)
Murray, A.B. Co., Inc., NJ (ee)
National Electric Products Corp., Pa (ee)
National Supply Co., Industrial Products Div., Calif (o,q,w)
National Tube Div., U.S. Steel Corp., Pa (ee)
National-Standard Co., Mich (dd,ff)
New Jersey Metals Co., NJ (w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Parker Metal Goods Co., Mass (ff)
Pencoyd Steel & Forge Corp., Pa (o,q,w)
Penn Precision Products, Inc., Pa (v,dd)
Precision Tube Co., Inc., Pa (ee)
Rathbone Corp., Mass (o,bb)
Republic Steel Corp., Ohio
(o,q,w,z,bb,cc,dd,ee,ff)—Ad pp 78-9
Reynolds Aluminum Supply Co., Ga (o,z,bb,cc,ee)
Riverside-Alloy Metal Div., H.K. Porter Co., Inc., NJ (bb,dd,ff)
Rodney Metals, Inc., NY (v,dd)
Rolled Alloys, Inc., Mich (o,q,z,bb,cc,dd,ee,ff)
Rolock, Inc., Conn (ff)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
Sandusky Foundry & Machine Co., Ohio
(ee)
Sandvik Steel, Inc., NJ
(dd,ee,ff)
Service Steel Div., Van Pelt Corp., Mich (ee)
Sharon Steel Corp., Pa (q,w,z,cc,dd)
Sharpsville Steel Fabricators, Inc., Pa (o,z,bb,dd)
Simonds Saw & Steel Co., Mass (o,cc)
Smith-Moon Steel Co., Kan (o,z,cc,dd)
Somers Brass Co., Inc., Conn
(v,dd)—Ad pp 136, 139
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (z,ff)
Sun Steel Co., Ill (cc,dd)
Superior Drawn Steel Co., Pa (o,bb,ff)
Superior Steel Corp., Pa (dd)
Superior Steel Div., Copperweld Steel Co., Pa (dd)
Superior Tube Co., Pa (ee)
Sylvania Electric Products, Inc., Parts Div., Pa
(ff)—Ad p 349
Techalloy Co., Inc., Pa (v,bb,dd,ff)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Ulbrich Stainless Steels Corp., Conn (dd)
Union Steel Corp., NJ (dd,ee)
United Screw & Bolt Corp., Ill (bb,cc,dd,ff)
U.S. Challenge & Challenge Co., Ill (bb)
U.S. Gasket & Shim Co., Ohio (cc,dd)
U.S. Steel Corp., Pa
(o,q,w,z,bb,cc,dd,ff)—Ad p 77
Universal-Cyclops Steel Corp., Pa (o,q,z,bb,cc,dd,ff)
Uniworld Research Corp. of America, Ohio (o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Vanadium-Alloys Steel Co., Pa (o,q,w,z,aa,bb,cc,ff)
Vulcan Rail & Construction Co., NY (o,dd,ee)
Vulcan-Kidd Steel Div., H.K. Porter Co., Inc., Pa (o,q,z,bb,ff)
Walmet Alloys Co., Mich
—Ad p 72
Wall Tube & Metal Products Co., Tenn (ee)
Wallingford Steel Co., Conn
(v,dd)—Ad p 352
Washington Steel Corp., Pa (cc,dd)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,w,z,bb,cc,dd,ee)
Whitehead Metal Products Co., Inc., NY (z,bb,cc,dd)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (z)
Worcester Wire Works Div., National-Standard Co, Mass (ff)

Steel, Heat and Corrosion Resistant—Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Foundries & Steel, Inc., NY
Aelco Foundries, Inc., Wis
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Precision Castings Co., Ohio
Alloy Steel Casting Co., Pa
American Brake Shoe Co., NY
American Cast Iron Pipe Co., Ala
American Steel Foundries, Ill
Apex Steel Corp., Ltd., Calif
Arwood Precision Castings Corp., NY
Babcock & Wilcox Co., Pa
Beaver Valley Alloy Foundry Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Bonney-Floyd Co., Ohio
Brinkerhoff Brass & Bronze Works, Inc., NY
Calorizing Co., Pa
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Commercial Steel Casting Co., Ohio
Copper Alloy Corp., NJ
Crucible Steel Co. of America, Pa
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Donegal Steel Foundry Co., Pa
Driver, Wilbur B. Co., NJ
Duraloy Co., Pa
Duriron Co., Inc., Ohio
Electric Steel Foundry Co., Ore
Electro-Alloys Div., American Brake Shoe Co., Ohio
Empire Steel Castings, Inc., Pa
Fahralloy Co., Ill
Fort Pitt Steel Casting Div., Pittsburgh Steel Foundry Corp., Pa
Frasse, Peter A. & Co., Inc., NY
General Alloys Co., Mass
General Electric Co., Foundry Dept., NY
Grede Foundries, Inc., Wis
Hanford Foundry Co., Calif
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Industrial Stainless Steels, Inc., Mass
Ingersoll-Rand Co., NJ
Janney Cylinder Co., Pa
Johnson, A. & Co., Inc., NY
Jones & Laughlin Steel Corp., Strip Steel Div., Ohio (dd)
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries Div., Thompson Products, Inc., Ohio
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan
Lebanon Steel Foundry, Pa
Los Angeles Steel Casting Co., Calif
Manco Products, Inc., Mich
Massillon Steel Casting Co., Ohio
Michigan Steel Casting Co., Div. of Consolidated Foundries & Mfg. Corp., Mich
Midwest Precision Castings Co., Ohio
Misco Precision Casting Co., Mich
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
National Supply Co., Industrial Products Div., Calif
Ohio Steel Foundry Co., Ohio
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla.
Perfecto Cast, Calif
Picco, Inc., Calif

Letters in ( ) indicate materials and forms—turn page for key

Pittsburgh Steel Foundry Corp., Pa
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Ross-Meehan Foundries, Tenn
Sandusky Foundry & Machine Co., Ohio
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Skookum Co., Inc., Ore
Stainless Foundry & Engineering, Inc., Wis
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Stanwood Corp., Ill
Star Heel Plate Co., Inc., NJ
Superior Foundry, Inc., Ohio
Symington-Gould Corp., NY
Texas Foundries, Inc., Tex
Thompson Products, Inc., Valve Div., Ohio
Union Iron Works, Wash
U.S. Pipe & Foundry Co., Ala
Uniworld Research Corp. of America, Ohio
Utility Steel Foundry, Calif
Vollrath Co., Contract Div., Wis
Wall Colmonoy Corp., Stainless Process Div., Mich
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Materials Mfg. Dept., Pa
Wisconsin Centrifugal Foundry, Inc., Wis

Steel, Low Alloy

Acme Tube, Inc., NJ (ee)
Acme-Newport Steel Co., Ky (z,cc,ee)
Advance Screw Products Co., Inc., Wis
Advance Stamping Co., Mich (dd)
Alan Wood Steel Co., Pa (o,q,w,z, cc,dd)
Alco Products, Inc., NY (q,aa)
Alloy Metal Products, Inc., Iowa (o, q,w)
Alofs Mfg. Co., Mich (cc,dd,ff)
Amalgamated Steel Corp., Ohio (o, bb)
American Cast Iron Pipe Co., Ala (ee)
American Steel & Wire Div., U.S. Steel Corp., Ohio
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (bb, ff)
Arcos Corp., Pa (ff)
Aristoloy Steel Div., Copperweld Steel Co., Ohio (o,q)
Armco Steel Corp., Ohio (z,cc,dd)
Armco Steel Corp., Sheffield Div., Mo (o,q,w,z,bb,cc,ff)
Arrow Metal Products Corp., NJ (cc)
Atlantic Steel Co., Ga (o)
Austenal, Inc., NY (w)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Bethlehem Steel Co., Pa (o,q,z,bb,cc, dd)
Biddle Screw Products Co., Ind (bb)
Bliss & Laughlin, Inc., Ill (o)
Budek & Bock Spring Mfg. Co., Ill (dd,ff)
Burkhardt Steel Co., Colo (o,z,cc,dd)
Byers, A.M. Co., Pa (o,q,w,z)
California Metal Enameling Co., Calif (cc)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd, ff)
Castle, A.M. & Co., Ill (o,q)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)
Connors Steel Div., H.K. Porter Co., Inc., Ala (o,q)
Crucible Steel Co. of America, Titanium & Vacuum Metals Product Div., Pa (o,q,w,bb,cc,dd)
Curtiss-Wright Corp., Metals Processing Div., NY (ee,ff)
Dixon Sintaloy, Inc., Conn (o)
Eastern Rolling Mills, Inc., NY (cc,dd)
Empire-Reeves Steel Div., Universal-Cyclops Steel Corp., Pa (z,cc)
Enterprise Wheel & Car Corp., Va (z,cc)
Frasse, Peter A. & Co., Inc., NY (o,z,bb,cc,dd,ee,ff)
Globe Steel Abrasive Co., Ohio (aa)
Great Lakes Steel Corp., Div. of National Steel Corp., Mich (z,cc,dd)
Hardy, Charles, Inc., N (aa)
Hayden Wire Works, Inc., Mass (o,bb, ff)
Higbie Mfg. Co., Mich (ee)
Hoeganaes Sponge Iron Corp., NJ (aa)
Inland Steel Co., Ill (o,z,cc,dd)
Jones & Laughlin Steel Corp., Pa (o, q,z,cc,dd,ee,ff)
Jones & Laughlin Steel Corp., Strip Steel Div., Ohio (dd)
Kaiser Steel Corp., Calif (o,q,w,z,bb, cc,dd)
Keystone Drawn Steel Co., Pa (q)
Kinkead Industries, Inc., Ill (cc,dd)
Larson, Charles E. & Sons Inc., Ill (o)
La Salle Steel Co., Ill (o)
Levinson Steel Co., Pa (cc)
Lincoln Steel Corp., Neb (cc)
Lukens Steel Co., Pa (w,z)—Ad pp 66-7
Lundquist Tool & Mfg. Co., Inc., Mass (cc,dd)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd,ee)
McInnes Steel Co., Pa (o)
Mechanical Steel Tubing Corp., NY (ee)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Michigan Seamless Tube Co., Mich (ee)
Midvale-Heppenstall Co., Pa (w)
Murray, A.B. Co., Inc., NJ (ee)
National Tube Div., U.S. Steel Corp., Pa (ee)
National-Standard Co., Mich (dd,ff)
National-U.S. Radiator Corp., Plastic Metals Div., Pa (aa)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb)
Northwestern Steel & Wire Co., Ill (o,q,w,z,bb,ff)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (ff)
Parker Metal Goods Co., Mass (ff)
Pencoyd Steel & Forge Corp., Pa (o,q,w)
Peninsular Steel Co., Mich (o,q,z)
Pittsburgh Forgings Co., Mich (o,q)
Rathbone Corp., Mass (o,bb)
Reliance Div., Eaton Mfg. Co., Ohio (o,ff)
Republic Steel Corp., Ohio (o,q,w,z,bb,cc,dd,ee,ff)—Ad pp 78-9
Revere Copper & Brass, Inc., NY (ee)
Rodney Metals, Inc., NY (v,dd)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,z,bb,cc,dd,ee,ff)
St. Louis Steel Casting, Inc., Mo (n)
Sandusky Foundry & Machine Co., Ohio (ee)
Sandvik Steel, Inc., NJ (dd)—Ad p 68
Sawhill Tubular Products, Inc., Pa (ee)
Scudder, E.J. Foundry & Machine Co., NJ (bb,ee)
Service Steel Div., Van Pelt Corp., Mich (ee)
Sharon Steel Corp., Pa (q,w,z,cc,dd, ee)
Sharpsville Steel Fabricators, Inc., Pa (o,z,bb,cc)
Simonds Saw & Steel Co., Mass (o, cc)
Smith-Moon Steel Co., Inc., Kan (o, z,cc)
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa (q,w)
Star Heel Plate Co., Inc., NJ (ee,ff)
Sun Steel Co., Ill (o,q,z,bb,cc,dd)
Superior Drawn Steel Co., Pa (o, bb,ff)
Superior Tube Co., Pa (ee)
Thomas Strip Div., Pittsburgh Steel Co., Pa (dd)—Ad pp 74-5
Thompson Wire Co., Mass (dd)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Union Iron Works, Wash (cc)
Union Steel Corp., NJ (dd)
United Screw & Bolt Corp., Ill (bb, cc,dd,ff)
U.S. Steel Corp., Pa (o,q,w,z,bb,cc,dd,ee)—Ad p 77
Vanadium-Alloys Steel Co., Pa (o,q,w, z,aa,bb,cc,ff)
Washburn Wire Co., Phillipsdale Div., RI (q,bb,dd)
Weirton Steel Co., Div. of National Steel Corp., W.Va (z,cc,dd)
Western Automatic Machine Screw Co., Div. of Standard Screw Co., Ohio (o)
Wheelock, Lovejoy & Co., Inc., Mass (o,q,bb)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (w,z)
Wilder Mfg. Co., Inc., Calif (o,z,cc)
Wyckoff Steel Co., Pa (o,z)
Youngstown Sheet and Tube Co., Ohio (o,z,cc,dd,ee)

Steel, Low Alloy —Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Adirondack Foundries & Steel, Inc., NY
Allied Steel Castings Co., Ill
All-Metals Precision Casting Corp., NY
Alloy Cast Steel Co., Ohio
Alloy Precision Castings Co., Ohio
Alloy Steel & Metals Co., Calif
American Cast Iron Pipe Co., Ala
American Manganese Steel Div., American Brake Shoe Co., Ill
American Steel Foundries, Ill
Arwood Precision Castings Corp., NY
Atlantic Foundry Co., Ohio
Atlantic Steel Castings Co., Pa
Austenal, Inc., NY
Auto Specialties Mfg. Co., Mich
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Birdsboro Steel Foundry & Machine Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Commercial Steel Casting Co., Ohio
Crucible Steel Co. of America, Pa
Crucible Steel Casting Co., Pa
Dayton Steel Foundry Co., Ohio
Electric Steel Castings Co., Ind
Electric Steel Foundry Co., Ore
Electrocast Steel Foundry Co., Ill
Empire Foundry Co., Inc., Calif
Empire Steel Castings, Inc., Pa
Federal Steel Products Corp., Tex
General Electric Co., Foundry Dept., NY
Glover Machine Works, Ga
Grafton Foundry Co., Wis
Grede Foundries, Inc., Wis
Gunite Foundries Corp., Ill
Hartford Electric Steel Corp., Conn
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Hughes Tool Co., Tex
Humphrey Castings, Inc., Calif
Illinois Precise Casting Co., Ill
Jones & Laughlin Steel Corp., Pa
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries Div., Thompson Products, Inc., Ohio
Lebanon Steel Foundry, Pa
Lectromelt Casting Div., Akron Standard Mold Co., Ohio
Los Angeles Steel Casting Co., Calif
Mackintosh-Hemphill Div., E.W. Bliss Co., Pa
Massillon Steel Casting Co., Ohio
Mercast Mfg. Corp., Calif
Midwest Precision Castings Co., Ohio
Minneapolis Electric Steel Casting Co., Minn
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
Monroe Steel Castings Co., Mich
National Iron Co., Minn
National Malleable & Steel Castings Co., Ohio
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
National Supply Co., Industrial Products Div., Calif
Oklahoma Steel Castings Div., American Steel & Pump Corp., Okla
Olympic Steel Works, Wash
Omaha Steel Works, Neb
Pelton Steel Casting Co., Wis
Perfecto Cast, Calif
Picco, Inc., Calif
Pittsburgh Steel Foundry Corp., Pa
Posey Iron Works Inc., Pa
Pratt & Letchworth Div., Dayton Malleable Iron Co., Inc., NY
Precision Founders, Inc., Calif
Quaker Alloy Casting Co.. Pa
Quality Electric Steel Castings, Inc., Tex
Racine Steel Castings Co., Belle City Malleable Div., Wis
Reliance Steel Castings Co., Pa
Ross-Meehan Foundries, Tenn
St. Louis Steel Casting, Inc., Mo
Sandusky Foundry & Machine Co., Ohio
Sawbrook Steel Castings Co., Ohio
Scudder, E.J. Foundry & Machine Co., NJ
Sharpsville Steel Fabricators, Inc., Pa
Sivyer Steel Casting Co., Wis
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Strong Steel Foundry Co., NY
Superior Foundry, Inc., Ohio
Swedish Crucible Steel Co., Mich
Texas Foundries, Inc., Tex
Texas Steel Co., Tex
Union Iron Works, Wash
Union Spring & Mfg. Co., Pa
Unitcast Corp., Ohio —Ad p 330
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Utility Steel Foundry, Calif
Valley Steel Casting Co., Mich
Vulcan Iron Works, Pa
Washington Iron Works, Wash
West Steel Casting Co., Ohio
Westlectric Castings, Inc., Calif
Worthington Corp., NJ

Steel, Specialty

(electrical, magnet, nitriding, etc.)

Acme-Newport Steel Co., Ky (cc)
Allegheny Ludlum Steel Corp., Pa (o,q,z,bb,ff)
Alloy Metal Powders, Inc., NY (aa)
Amalgamated Steel Corp., Ohio (o,bb)
American Silver Co., Inc., NY (v,bb)
American Steel & Wire Div., U.S. Steel Corp., Ohio (ff)
Armco Steel Corp., Ohio (o,q,v,z,bb,cc, dd,ee,ff)
Arnold Engineering Co., Ill (dd)
Atlantic Steel Co., Ga (o)
Austenal, Inc., NY (w)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,dd)
Chicago Development Corp., Md (aa)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (o,q,w,z,bb,cc,ff)

Crucible Steel Co. of America, Pa (o, q,w,z,bb,cc)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,z,bb,cc,dd,ff)
Edgcomb Steel & Aluminum Corp., NJ (o,cc,dd)—Ad p 70
Hamilton Watch Co., Precision Metals Div., Pa (v,cc,dd,ff)
Hoeganaes Sponge Iron Corp., NJ (aa)
Inland Steel Co., Ill (cc)
Johnston & Funk Titanium Corp., Ohio (w,bb,ff)
Jones & Laughlin Steel Corp., Pa (o, z,cc)
Larson Tool & Stamping Co., Mass (o)
La Salle Steel Co., Mo (bb)
Latrobe Steel Co., Mo (o,q,w)
Lukens Steel Co., Pa (w,z)—Ad pp 66-67
Mallory-Sharon Metals Corp., Ohio (cc)
Manganese Steel Forge Co., Pa (o,z, bb,cc,dd,ff)
McInnes Steel Co., Pa (o)
Midvale-Heppenstall Co., Pa (q,w)
National Supply Co., Pa (o,q)
National Supply Co., Industrial Products, Div., Calif (o,q,w)
Penn Precision Products, Inc., Pa (v, dd)
Republic Steel Corp., Ohio (o,q,w,z,bb,cc,dd,ee)
Ryerson, Joseph T. & Son, Inc., Ill (o)
Sandvik Steel, Inc., NJ (o,bb,dd)—Ad p 68
Simonds Saw and Steel Co., Mass (cc, dd)
Stulz-Sickles Co., NJ (o,q,z,bb)
Superior Steel Corp., Pa (dd)
Sylvania Electric Products Inc., Parts Div., Pa (ff)—Ad p 349
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q,ee)
U.S. Steel Corp., Pa (o,q,w,z,bb,cc,dd)—Ad p 77
Universal-Cyclops Steel Corp., Pa (o, q,z,bb,cc,dd,ff)
Utica Metals Div., Kelsey-Hayes Co., NY (o,q,w,z,bb,cc,dd,ff)
Vanadium-Alloys Steel Co., Pa (o,q,w, z,aa,bb,cc,ff)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd, ee)

Steel, Specialty —Castings

Acco Steel Casting Div., American Chain & Cable Co., Inc., Pa
Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Precision Castings Co., Ohio
American Steel Foundries, Ill
Arwood Precision Castings Corp., NY
Austenal, Inc., NY
Beaver Valley Alloy Foundry Co., Pa
Bethlehem Steel Co., Pa
Blaw-Knox Co., Pa
Bone Engineering Corp., Calif
Campbell, Wyant & Cannon Foundry Co., Div. of Textron, Inc., Mich
Carondelet Foundry Co., Mo
Crobalt, Inc., Mich
Crucible Steel Co. of America, Pa
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Electric Steel Foundry Co., Ore
General Electric Co., Foundry Dept., NY
Grede Foundries, Inc., Wis
Hica, Inc., La
Howard Foundry Co., Ill
Humphrey Castings, Inc., Calif
Janney Cylinder Co., Pa
Johnston & Funk Titanium Corp., Ohio
Kay-Brunner Steel Products, Inc., Calif
Kolcast Industries, Div., Thompson Products, Inc., Ohio
Lebanon Steel Foundry, Pa
Los Angeles Steel Casting Co., Calif
Manco Products, Inc., Mich
Mercast Mfg. Corp., Calif
Midwest Precision Castings Co., Ohio
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Pa
National Supply Co., Industrial Products Div., Calif
Overmyer Mould Co., Inc., Ind
Perfecto Cast, Calif
Picco, Inc., Calif
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Quality Electric Steel Castings, Inc., Tex
Standard Steel Works Div., Baldwin-Lima-Hamilton Corp., Pa
Star Heel Plate Co., Inc., NJ
Stulz-Sickles Co., NJ
Swedish Crucible Steel Co., Mich
Texas Foundries, Inc., Tex
United Shoe Machinery Corp., Mass
U.S. Pipe & Foundry Co., Ala
Utility Steel Foundry, Calif
Vanadium-Alloys Steel Co., Pa
Wall Colmonoy Corp., Stainless Process Div., Mich
West Steel Casting Co., Ohio
Westinghouse Electric Corp., Pa
Wisconsin Centrifugal Foundry, Inc., Wis

Steel, Tool and Die

A & A Die Casting Co., Calif (o,z,bb, cc)
Able Tool & Engineering Co., Ill (z)
Advance Stamping Co., Mich (o,z,bb)
Allegheny Ludlum Steel Corp., Pa (o,q,z,bb,ff)—Ad p 80
Alofs Mfg. Co., Mich (o,z,bb)
Amalgamated Steel Corp., Ohio (o,bb)
Anchor Drawn Steel Co., Div. of Vanadium Alloys Steel Co., Pa (bb,ff)
Austenal, Inc., NY (w)
Bethlehem Steel Co., Pa (o,q)
Biddle Screw Products Co., Ind (gg)
Cannon-Muskegon Corp., Mich (w)
Carpenter Steel Co., Pa (o,q,w,bb,cc, ff)
Columbia Tool Steel Co., Ill (o,q,w,bb)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,w,z,bb,cc,dd,ff)
Dahlin, C.A. Co., Ill (o,z,cc,dd)
Delaware Tool Steel Corp., Del (o)
Edgcomb Steel & Aluminum Corp., NJ (o,q,w,bb)
Firth Sterling, Inc., Pa (o,q,bb,dd)
Forg, Peter Mfg. Co., Mass (cc)
Frasse, Peter A. & Co., Inc., NY (o)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (o,z, bb)
Heller Tool Co., Ohio (o)
Inshield Die & Stamping Co., Ohio (o)
Jones & Laughlin Steel Corp., Pa (o,z,bb)
Kidd Drawn Steel Co., Pa (o,bb)
Kinkead Industries, Inc., Ill (o,z,bb)
Larson, Charles E. & Sons, Inc., Ill (o)
Latrobe Steel Co., Pa (o,q,w)
Lundquist Tool & Mfg. Co., Inc., Mass (o,z,bb)
Midvale-Heppenstall Co., Pa (q,w)
National Supply Co., Industrial Products Div., Calif (o,q,w)
Norrich Plastics Corp., Screw Machine Products Div., NY (o,bb,ee)
Norwalk Powdered Metals, Inc., Conn (aa)
Ormond Mfg., Co., Inc., NJ (cc,dd, ff)
Pencoyd Steel & Forge Corp., Pa (o, q,w)
Peninsular Steel Co., Mich (o,q,z)
Pittsburgh Tool Steel Wire Co., Pa (o,bb)
Republic Steel Corp., Ohio (o,q)
Ross-Meehan Foundries, Tenn (o)
Ryerson, Joseph T. & Son, Inc., Ill (o,q,bb,cc)
Sandvik Steel, Inc., NJ (o)
Sharpsville Steel Fabricators, Inc., Pa (bb)
Simonds Saw & Steel Co., Mass (o, cc)
Superior Tube Co., Pa (ee)
Timken Roller Bearing Co., Steel & Tube Div., Ohio (o,q)
Tube Reducing Corp., NJ (ee)
Universal-Cyclops Steel Corp., Pa (o, q,z,bb,cc,dd,ff)
Vanadium-Alloys Steel Co., Pa (o, q,w,z,aa,bb,cc,ff)
Vulcan-Kidd Steel Div., H.K. Porter Co. Inc., Pa (o,q,w,bb,ff)
Walmet Alloys Co., Mich —Ad p 72
Wheelock, Lovejoy & Co., Inc., Mass (o,q,bb)
Wilder Mfg. Co., Inc., Calif (o,bb)
Ziv Steel & Wire Co., Ill (o,q)

Steel, Tool and Die —Castings

Allegheny Ludlum Steel Corp., Pa
All-Metals Precision Casting Corp., NY
Alloy Precision Casting Co., Ohio
American Foundry & Machine Div., Eimco Corp., Utah
Apex Steel Corp., Ltd., Calif
Arwood Precision Castings Corp., NY
Atlantic Steel Castings Co., Pa
Austenal, Inc., NY
Beaver Valley Alloy Foundry Co., Pa
Bone Engineering Corp., Calif
Carondelet Foundry Co., Mo
Crucible Steel Co. of America, Pa
Crucible Steel Casting Co., Pa
Curtiss-Wright Corp., Metals Processing Div., NY
Empire Steel Castings, Inc., Pa
General Electric Co., Foundry Dept., NY
Hica, Inc., La
Hitchiner Mfg. Co., Inc., NH
Howard Foundry Co., Ill
Illinois Precise Casting Co., Ill
Kolcast Industries Div., Thompson Products Inc., Ohio
Manco Products, Inc., Mich
Midwest Precision Castings Co., Ohio
Misco Precision Casting Co., Mich
Missouri Steel Castings Co., Mo
National Precision Casting Corp., Div. of Beryllium Corp., Pa
National Supply Co., Industrial Products Div., Calif
Precision Founders, Inc., Calif
Quaker Alloy Casting Co., Pa
Ross-Meehan Foundries, Tenn
Star Heel Plate Co., Inc., NJ
Swedish Crucible Steel Co., Mich
Vanadium-Alloys Steel Co., Pa
Westinghouse Electric Corp., Pa

Strip

(see specific material)

Strippable Coatings

(see Organic Coatings)

Styrene

(see Polystyrene)

Styrene-Butadiene Rubber

Adhesive Products Corp., NY (x)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)
American Synthetic Rubber Corp., NY (p)
Anderson Assoc., Inc., Ohio (y)
Auburn Plastics, Inc., NY (bb,cc,dd)
Auburn Rubber Co., Inc., Ind (cc)
Automotive Rubber Co., Inc., Mich (cc,dd)
Belko Corp., Md (y)
Borden Co., Chemical Div., NY (p)
Campco Div., Chicago Molded Products Corp., Ill (cc)

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb,cc,dd,ee)
Copolymer Rubber and Chemical Corp., La (p)
Dayton Rubber Co., Ohio (y,bb,cc,dd,ee)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
Electrofilm, Inc., Calif (t)
Faultless Rubber Co., Ohio (u,y,bb,ee)
Firestone Tire & Rubber Co., Ohio (p)
Garlock Packing Co., NY (y,bb,cc,dd,ee)
Geauga Industries Co., Ohio (y,bb,dd)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Goodrich-Gulf Chemicals, Inc., Ohio (p)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Goshen Rubber Co., Inc., Ind (y)
Heresite & Chemical Co., Wis (p)
Hewitt-Robins, Inc., Conn (cc,ee)
Home Rubber Co., NJ (y,bb,cc,dd)
Koppers Co., Inc., Pa (p)
Lus-Trus Corp., Mich (cc)
Maloney, F.H. Co., Tex (y)
Marbon Chemical Div., Borg-Warner Corp., Ind (p,u,x,y)—Ad pp 210-11
Martin Rubber Co., Inc., NJ (y,dd,ee)
Mid-States Rubber Products, Inc., Ind (y)
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x,y)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Parker, Stearns & Co., Inc., NY (cc,dd)
Phillips Chemical Co., Plastics Sales Div., Okla (p)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,y,cc,dd,ee)
Roth Rubber Co., Ill (y,cc)
Rubatex Div., Great American Industries Inc., Va (u)
Shell Chemical Corp., NY (p)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., SC (bb,cc,dd,ee)
Stockwell Rubber Co., Inc., Pa (y,bb,cc,dd)
Technical Specialties Co., NY (dd)
Texas-U.S. Chemical Co., NY (p)—Ad pp 218-19
Toyad Corp., Pa (u)
United Rubber & Chemical Co., W.Va (p)
U.S. Rubber Co., NY (p)
U.S. Rubber Co., Kem-Blo Dept., Conn (u)—Ad p 216
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Vulcanized Rubber & Plastics Co., Pa (y)
Western Felt Co., Ill (y,cc,dd,ee)
Westlake Plastics Co., Pa (t,bb,cc,dd)
Williams-Bowman Rubber Co., Ill (y,bb,cc)

Superalloys

(see Nickel; Cobalt; Chromium)

Synthetic Fibers

(see specific polymer)

Tantalum and Its Alloys

Alpha Metals, Inc., NJ (v,cc,dd)
American Silver Co., NY (v,dd)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (ee)
Columbia-National Corp., Mass (w)
Electro Metallurgical Co., Div. of Union Carbide Corp., NY (w)
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 138-39
Foote Mineral Co., Pa (aa)
General Plate Div., Metals & Controls Corp., Mass (v,dd)
Hamilton Watch Co., Precision Metals Div., Pa (v,dd)
Hardy, Charles, Inc., NY (aa)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (bb,cc,dd)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
Kawecki Chemical Co., NY (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)
Kennametal, Inc., Pa (o,v,aa,dd,ff)—Ad p 255
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (dd)
Mallory, P.R. & Co., Inc., Ind (bb,dd)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Metal Hydrides, Inc., Mass (aa)
Metals & Controls Corp., Mass (v,dd,ff)
National Research Corp., Mass (v,w,aa,bb,cc,ee,ff)
Oregon Metallurgical Corp., Ore (w)
Shieldalloy Corp., NJ (aa)
Wah Chang Corp., NY (v,aa,bb,dd,ff)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,v,w,z,bb,cc,dd,ee)

Tapes, Adhesive

American Tape Co., Mich
Angier Adhesives Div., Interchemical Corp., Mass
Beck, I. & Sons, Inc., NY
Coating Products, Inc., NJ —Ad p 291
Connecticut Hard Rubber Co., Conn
Cycleweld Div., Chrysler Corp., Mich
Dutch Brand Div., Johns-Manville Corp., Ill
Electro Technical Div., Sun Chemical Corp., NJ
Enflo Corp., NJ
Fasson Products, Ohio
Foss Mfg. Co., Plastics Div., Id
Hampton Mfg. Co., NY
Insulation Mfrs. Corp., Ill
Interchemical Corp., NY
Johns-Manville Corp., NY
Kinkead Industries, Inc., Ill
Lundquist Tool & Mfg. Co., Inc., Mass
Magnesium Co. of America, Ind
Mystik Adhesive Products, Inc., Ill
Narmco Resins & Coatings Co., Calif
Permacel-LePage's, Inc., NJ
Presstite-Keystone Engineering Products Co., Mo
Respro Div., General Tire & Rubber Co., RI
Rubber & Plastics Compound Co., Inc., NY
Shell Chemical Corp., NY
Superior Plastics, Inc., Ill
Technical Tape Corp., NY

Teflon

(see Fluorocarbons)

Terne Plate

(see Precoated Metals)

Tetrafluoroethylene

(see Fluorocarbon)

Tin and Its Alloys

Alpha Metals, Inc., NJ (n,o,q,v,w,aa,bb,cc,dd)
American Metal Climax, Inc., NY (w,aa)
American Smelting & Refining Co., NY (n,o,w)
Anchor Metal Co., Inc., NY (w,aa)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,aa,cc,dd,ff)
Caspers Tin Plate Co., Ill (cc,dd)
Crown Metal Co., Wis (n,ee,ff)
Division Lead Co., Ill (o,v,w,cc,dd,ee,ff)
Dixon Sintaloy, Inc., Conn (o)
Empire Metal Co., NY (n,o,q,w,bb,ff)
Farrelloy Co., Pa (aa,ff)
Glidden Co., Chemicals-Pigments-Metals Div., Md (aa)—Ad p 347
Greenback Industries, Inc., Mich (aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hi-Grade Alloy Corp., Ill (n,o,v,w,ee)
Hodgson Foundry Co., Ill (n)
Indium Corp. of America, NY (dd,ff)
Johnston Foil Mfg. Co., Mo (v,cc)
Korhumel Steel and Aluminum Co., Ill (z,dd)
McGean Chemical Co., Ohio (n,o,aa)
Metal & Thermit Corp., NJ (n,w,aa)
Metallizing Engineering Co., Inc., NY (ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Modern Plating Corp., Ill (n)
National Lead Co., NY (n,o,q,w,z,aa,bb,cc,dd,ee)
Nesor Alloy Products Co., NJ (ff)
Norwalk Powdered Metals, Inc., Conn (aa)
Pittsburgh Smelting & Refining Co., Pa (o,w)
Republic Metals Co., Inc., NY (n,o,v,w,cc,ee,ff)
Revere Copper & Brass, Inc., Foil Div., NY (v)
River Smelting & Refining Co., Ohio (o)
Rotometals, Calif (o,v,w,aa)
Sall, George Metals Co., Inc., Pa (w)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)

Tinplate

(see Precoated Metals)

Titanium and Its Alloys

Alpha Metals, Inc., NJ (v)
American Silver Co., NY (v,dd)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Belmont Smelting & Refining Works, Inc., NY (aa)—Ad p 130
Bridgeport Brass Co., Conn (o,bb,ee)
Carpenter Steel Co., NJ (ee)
Central Fabricators, Inc., Ohio (z,bb,cc,ee)
Chicago Development Corp., Md (aa)
Crucible Steel Co. of America, Pa (o,q,w,z,bb,cc,dd,ee,ff)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (o,q,v,z,bb,cc,dd,ee,ff)
Damascus Tube Co., Pa (ee)—Ad p 351
Driver-Harris Co., NJ (v,dd)
du Pont de Nemours, E.I. & Co., Inc., Del (w)
Electric Steel Foundry Co., Ore (o,q,w,bb,ee)
Electro Metallurgical Co., Div. of Union Carbide Corp., NY (aa)—Ad p 134
Firth Sterling, Inc., Pa (o,q,w,bb,dd)
Foote Mineral Co., Pa (o,bb)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum Div., Harvey Machine Co., Inc., Calif (o,q,w,bb,ee)
Hexcel Products, Inc., Calif (v)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
King Laboratories, Inc., NY (w,aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (o,dd)
Mallory, P.R. & Co., Inc., Ind (o,z,bb,cc,dd,ee)
Mallory-Sharon Metals Corp., Ohio (o,q,w,z,bb,cc,dd,ff)—Ad p 137
Metal Forming Corp., Ind (ee)
Metal Hydrides, Inc., Mass (aa)
Metal & Thermit Corp., NJ (w)
Metals & Controls Corp., Mass (v,cc,dd)
Metals Disintegrating Co., Inc., NJ (aa)
Michigan Seamless Tube Co., Mich (ee)
National Lead Co., NY (o,q,w,z,bb,cc,dd,ee,ff)
National-Standard Co., Mich (ff)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Oregon Metallurgical Corp., Ore (o,q,w)
Pioneer Aluminum, Inc., Calif (z)
Republic Steel Corp., Ohio (o,w,z,cc,ee)
Rigidized Metals Corp., NY (cc,dd)
Rodney Metals, Inc., NY (v,dd)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa (ee)
Techalloy Co., Inc., Pa (dd,ff)
Titanium Metals Corp. of America, NY (o,q,z,aa,bb,cc,dd)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (ee)
Tube Distributors Co., Inc., NY (ee)
Tube Reducing Corp., NJ (ee)
Ullmann, Inc., Wis (o,ee)
United International Research, Inc., NY (aa)
U.S. Industrial Chemicals Co., Div. of National Distillers & Chemical Corp., NY (w)
Vanadium Corp. of America, NY (w)
Worcester Wire Works Div., National-Standard Co., Mass (ff)
Youngstown Welding & Engineering Co., Ohio (ee)

Tool Steels

(see Steel)

Transfer Moldings

(see Moldings)

Trifluorochloroethylene

(see Fluorocarbon)

Tubing, Pipe

Ace Plastic Co., NY (k,l)
Acme Tube, Inc., NJ (a,b,c,g)
Acme-Newport Steel Co., Ky (g)
Albert Pipe Supply Co., Inc., NY (a,g)
Albright Son & Co., Pa (g)

Suppliers of Materials

Allegheny Ludlum Steel Corp., Pa (g)

Allied Tube Corp., Pa (a,g)

Aluminum Co. of America, Pa (a,e)

Amco Plastic Pipe Co., Calif (k)
American Agile Corp., Ohio (k)
American Brass Co., Sub. of Anaconda Co., NY (a,b,g)

American Cast Iron Pipe Co., Ala (c,f,g)—Ad p 329

American Manganese Steel Div., American Brake Shoe Co., Ill (g)
American Molding Co., Calif (k)
American Nickel Alloy Mfg. Corp., NY (f)
American Pipe & Construction Co., Ore (g)
American Plastics Corp., NY (k)
American Reed Co., Inc., Mass (a)
American Sheet Metal Works, Inc., Conn (a,b,g)
American Smelting & Refining Co., NY (d)
Ampco Metal, Inc., Wis (b)

Anchor Plastics Corp., NY (k)—Ad p 340

Anesite Co., Ill (k)
Apex Reinforced Plastics Div., White Sewing Machine Corp., Ohio (l)
Armco Steel Corp., Ohio (g)
Arvin Industries, Inc., Ohio (a,g)
Atlantic India Rubber Works, Inc., Ill (m)
Atlantic Steel Co., Ga (a,g)
Atlas Mineral Products Co., Pa (k)
Auburn Plastic Engineering, Ill (k)
Avon Tube Div., Higbie Mfg. Co., Mich (g)
Babcock & Wilcox Co., Tubular Products Div., Pa (c,g,h)
Barium Steel Corp., NY (g)
Bassons Industries Corp., NY (k)
Benada Aluminum Products Co., Ohio (a)
Bethlehem Steel Co., Pa (c,g)

Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (f,g)—Ad p 342

Bohn Aluminum & Brass Corp., Mich (a)
Borden Co., Chemical Div., NY (k)
Brainard Steel Div., Sharon Steel Corp., Ohio (g)
Bridgeport Brass Co., Conn (a,b,h)
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b,f,g)
Broadway Mfg. Co., Wis (c,g)
Bundy Tubing Co., Mich (f,g)
Bunker Hill Co., Calif (d)
Burkhardt Steel Co., Colo (g)

Busada Mfg. Co., NY (c,g)—Ad p 356

Byers, A.M. Co., Pa (k)
Cadillac Plastic & Chemical Co., Mich (k,l)
Calfibe Co., Inc., Calif (k)
Carlon Products Corp., Ohio (k)
Carpenter Steel Co., Alloy Tube Div., NJ (g)
Cartwright, R. Tube Products Co., Mich (a,b,e,f,g)
Celluplastic Corp., NJ (k)
Channel Master Corp., NY (a)
Chase Brass & Copper Co., Conn (b)
Chemical Products Corp., RI (k)
Chicago Gasket Co., Ill (k)
Clayton Mark & Co., Ill (g)
Cleveland Steel Specialty Co., Inc., Ohio (g)
Colonial Alloys Co., Pa (a)
Colonial Art Co., Inc., Mass (k)
Colonial Plastics Mfg Co., Ohio (k)
Colorado Fuel and Iron Corp., Colo (g)
Conneaut Rubber & Plastics Co., Ohio (k,m)

Connecticut Hard Rubber Co., Conn (m)

Continental Can Co., Inc., NY (k)
Continental Copper & Steel Industries, Inc. (a,b,c,e,f,g,h)
Continental Rubber Works, Pa (m)
Continental-Diamond Fibre Corp., Del (l)
Copper and Brass Sales, Inc., Mich (a,b,e)
Cornell and Underhill, Inc., NJ (a,c,g)
Corson Industries, Pa (a)
Crane Co., Ill (k)
Crescent Plastics, Inc., Ind (k)
Crucible Steel Co. of America, Titanium & Vacuum Metals Products Div., Pa (f,g,h)
CrystalX Corp., Pa (k)

Curtiss-Wright Corp., Metals Processing Div., NY (g,h)—Ad p 364

Damascus Tube Co., Pa (f,g,h)—Ad p 351

Daubert Chemical Co., Ill (m)
Defiance Metal Products Co., Ohio (g)
Detroit Float & Stamping Co., Mich (b)
Division Lead Co., Ill (d)
Dixie Aluminum Corp., Ga (a)
Dixie Plastics Mfg. Co., La (k)
Dixon Corp., RI (k)
Dormont Mfg. Co., Pa (a,b,c,e)
Dow Chemical Co., Magnesium Div., Mich (e)
Drawn Metal Tube Co., Conn (b)
Dryden Rubber Div., Sheller Mfg. Co., Ill (m)
Easton Plastic Products Co., Inc., Pa (k)
Eclipse Plastic Industries, Inc., Fla (k)

Edgcomb Steel & Aluminum Corp., NJ (a)

Electric Steel Foundry Co., Ore (g,h)
Electronic Parts Mfg. Co., NJ (f)
Ellwood City Iron & Wire Co., Pa (c)
Emerson-Sack-Warner Corp., Mass (a,b,f,g)
Empire Metal Co., NY (d)
Evans Metal Co., Ga (d)
Federal Machine and Welder Co., Ohio (g)
Fibercast Corp., Okla (l)
FitzSimons Mfg. Co., Mich (g)
Flexaust Co., Div. of Callahan Zinc-Lead Co., Inc., NY (m)
Flexonics Corp., Ill (g)
Florence Pipe Foundry & Machine Co., NJ (c)
Formed Tubes, Inc., Mich (g)
Fox Products Co., Pa (a)
Franklin Plastics, Inc., Pa (k)

Frasse, Peter A. & Co., Inc., NY (a,g)—Ad p 365

Fromson Orban Co., Inc., NY (a,b,f,g)

Garlock Packing Co., NY (k)

Gates Rubber Co., Colo (k)
Geauga Industries Co., Ohio (m)

General Extrusions, Inc., Ohio (a)

General Motors Corp., Rochester Products Div., NY (g)
General Plastics Corp., Ohio (k)
Genesee Laboratories, Inc., NY (k)
Gering Products, Inc., NJ (k)
Glass Laboratories, NY (k)
Goodrich, B.F., Industrial Products Co., Ohio (k)
H & H Tube & Mfg. Co., Mich (a,b)
H-P Products, Inc., Ohio (g)
Hall Mfg. Co., NJ (k)
Hartwell, H.N. & Son, Inc., Mass (k)
Harvey Aluminum Div., Harvey Machine Co., Inc., Calif (a,h)
Hawkridge Bros. Co., Mass (a)
Haynes Stellite Co., Div. of Union Carbide Corp., Ind (f)
Hays Mfg. Co., Pa (l)
Hazledine, E.T. Co., Ind (g)
Heil Process Equipment Corp., Ohio (k)
Hi-Grade Alloy Corp., Ill (d)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Hungerford Plastics Corp., NJ (k)
Hussey, C.G. & Co., Div. of Copper Range Co., Pa (b)
Hydrawlik Co., NJ (k,m)
Imco Container Corp., Mo (k)
Industrial Pipe & Supply Co., Ill (g)
Industrial Plastic Fittings Co., Ohio (k)
Industrial Synthetics Corp., NJ (k)

International Nickel Co., Inc., NY (f)

Jackson Steel Products, Inc., NY (a,b,g)

Jarl Extrusions, Inc., NY (a)

Jet Specialties Co., Inc., Calif (k)
Johnson Metal Hose, Inc., Conn (b,f)
Johnson Plastic Corp., Ohio (k,m)
Johnson Rubber Co., Ohio (m)
Jones & Laughlin Steel Corp., Pa (g)
Jordan-Rogers Co., Calif (k)
Judsen Rubber Works, Inc., Ill (m)
K S H Plastics, Inc., Mo (k)

Kaiser Aluminum & Chemical Sales, Inc., Ill (a)

Kaiser Steel Corp., Calif (g)
Kenmore Machine Products, Inc., NY (b)
Kensico Tube Co., NY (b)
Kleiner Metal Specialties, Inc., NJ (g)
Koehler Mfg. Co., Mass (g)
Kraloy Plastic Pipe Co., Inc., Calif (k)
Kroh Wagner, Ill (a,g)
Laclede Steel Co., Mo (g)
Langsenkamp, F.H. Co., Ind (a,b)
Leach & Garner Co., Mass (b,f)
Lee Rubber & Tire Corp., Pa (m)
Lewin-Mathes Co., Mo (b)
Lewis & Saunders, NH (a,b,g)
Linderme Tube Co., Ohio (a,b)
Lock Joint Tube Co., Inc., Ind (g)
Lunn Laminates, Inc., NY (l)
Luzerne Rubber Co., NJ (k,m)
MacKenzie-Walton Co., RI (b)
Magline Inc., Mich (a,e)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Manufacturers Corp., Ohio (k)
Manufacturers & Fabricators, Inc., Ohio (f)
Mechanical Rubber Products Co., NY (l)
Mechanical Steel Tubing Corp., NY (a,g)
Meier Screw Products & Mfg. Co., Mich (a,b,c,e,g)
Melco Wire Products, Calif (a)
Metal Forming Corp., Ind (f,h)
Metal Goods Corp., Mo (a,b,f,g)
Midland Pipe & Supply Co., Ill (b,c,g)
Midvale-Heppenstall Co., Pa (g)
Minnesota Mining & Mfg. Co., Minn (k,l)
Missouri Boiler & Sheet Works, Mo (g)
Moore Drydock Co., Calif (g)
Morse, Fred W. Co., RI (a)

Mueller Brass Co., Mich (b)—Ad p 357

Murray, A.B. Co., Inc., NJ (a,b,f,g)
Naige Co., Inc., NY (k)
Narrangansett Boiler Works, Inc., RI (g)
National Copper & Smelting Co., Ohio (b)
National Electric Products Corp., Pa (g)
National Galvanizing Co., Pa (g)
National Gasket & Washer Mfg. Co., Inc., NY (k,l,m)
National Lead Co., NY (a,b,d)
National Lead Construction Co., Inc., NJ (d)
National Supply Co., Pa (g)
National Tube Div., U.S. Steel Corp., Pa (g)

National Vulcanized Fibre Co., Del (k,l)—Ad p 225

New England Tape Co., Inc., Mass (k)
Nikoh Tube Co., Ill (g)
Noera Mfg. Co., Conn (b,g)
Ohio Seamless Tube Div., Copperweld Steel Co., Ohio (g)
Ohio Steel Foundry Co., Ohio (f)
Olds Alloys Co., Calif (b,d,f)
Olin Mathieson Chemical Corp., Aluminum Div., NY (a)
Oregon Metallurgical Corp., Ore (h)
Pabst Engineering Equipment Co., Inc., NJ (a,b,c,e,f,g,h,j)
Parker Metal Goods Co., Mass (a,g)
Parker, Stearns & Co., Inc., NY (m)
Parker-Street Castings Co., Ohio (c)
Pencoyd Steel & Forge Corp., Pa (c,g)
Penn Brass & Copper Co., Pa (b)
Penn Extrusion Corp., Pa (a)
Perfex Plastics, Inc., Ill (k)
Pfister Aluminum Corp., NJ (a)
Phoenix Iron & Steel Co., Pa (g)
Pittsburgh Steel Co., Pa (j)
Pittsburgh Tube Co., Pa (g)
Plastex Co., Ohio
Plastic Pipe & Tube Corp., Calif (k)
Plastic Process Co., Inc., Calif (k)
Polyform Plastics Corp., NY (k)
Polymer Corp., Pa (k)
Porter, William Co., Calif (l)
Precision Extrusions, Inc., Ill (a)
Precision Tube Co., Inc., Pa (a,b,f,g)
Pressed Steel Co., Pa (f)
Prima Pipe Co., Tex (k)
Prince Rubber Co., Inc., NY (k,m)
Pyramid Moldings, Inc., Ill (g)
Pyramid Plastics, Inc., Ill (k,m)
Quaker Rubber Div., H.K. Porter Co., Pa (k,l,m)
Raybestos-Manhattan, Inc., NJ (m)
Reading Tube Corp., NY (b)
Reflin Co., Calif (k)
Reinhold Engineering & Plastics Co., Calif (k)
Reliance Plastic & Chemical Corp., NJ (k)
Ren Plastics, Inc., Mich (l)
Replac Corp., Ohio (k,l,m)
Republic Steel Corp., Ohio (g)

Republic Steel Corp., Steel & Tubes Div., Ohio (f,g,h)—Ad pp 78-9

Resin Industries, Calif (k)
Resistoflex Corp., NJ (k)
Revere Copper & Brass, Inc., NY (a,b,g)
Rex Corp., Mass (k)
Reynolds Metals Co., Va (a)
Rigidized Metals Corp., NY (a,g)

Roll Formed Products Co., Ohio (a,g)

Rolled Alloys, Inc., Mich (f,g)
Rolock, Inc., Conn (f)
Rome Turney Radiator Co., NY (a,b,g)
Roth Steel Products Co., Ohio (g)
Rotometals, Calif (d)
Rowland Products, Inc., Conn (k)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)

Sandusky Foundry & Machine Co., Ohio (b,f,g)

Sandvik Steel, Inc., NJ (g)
Sanford Plastics Corp., NY (k)
Saran Lined Pipe Co., Mich (g)

Letters in ( ) indicate materials and forms—turn page for key

Sawhill Tubular Products, Inc., Pa (f,g)
Schwab Plastics Corp., Mich (k,m)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Searjeant Metal Products, Inc., NJ (g)
Service Steel Co., Mich (g)
Shamban, W.S. & Co., Ind (k)
Sharon Steel Corp., Pa (g)
Sharpsville Steel Fabricators, Inc., Pa (b,g)
Shaw-Kendall Engineering Co., Ohio (a,b,c,f,g)
Shanango Furnace Co., Centrifugally Cast Products Div., Ohio (b,c,f)
Shoe Form Co., NY (k)
Sierra Electronic Corp., Calif (k)
Skyline Industries, Pa (k)
Small Tube Products, Inc., Conn (b)
Snyder, M.L. & Son, Inc., Pa (k)
South River Metal Products Co., Inc., NJ (a,e)
Southern Aluminum Finishing Co., Inc., Ga (a)
Southern Plastics Co., SC (k,m)
Southwestern Plastic Pipe Co., Tex (k)
Sparta Mfg. Co., Div. of U.S. Ceramic Tile Co., Ohio (k)
Spaulding Fibre Co., Inc., NY (e)—Ad p 217
Spiral-Glas Pipe Co., NJ (k)
Spuck Iron & Foundry Co., Mo (g)
Standard Metals Corp., Mass (b,f)
Standard Products Co., Mich (m)
Standard Tube Co., Mich (g)
Star Heel Plate Co., Inc., NJ (g)
Stockwell Rubber Co., Inc., Pa (k,m)
Stokes Molded Products, Div., Electric Storage Battery Co., NJ (k)
Sunlite Plastics, Inc., Wis (k)
Superior Tube Co., Pa (c,f,g,h)
Supplex Co., Div. of American Hard Rubber Co., NJ (k,m)
Surprenant Mfg. Co., Mass (k)
Swepco Tube Corp., NJ (f)
Synthane Corp., Pa (l)—Ad p 200
Taylor Fibre Co., Pa (l)
Technical Specialties Co., NY (m)
Texas Aluminum Co., Tex (a)
Thompson Pipe & Steel Co., Colo (c,f,g)
Timken Roller Bearing Co., Ohio (g)
Titanium Metals Corp. of America, NY (h)
Tompkins Products, Mich (a)
Torrington Co., Conn (a,g)
Trent Tube Co., Sub. of Crucible Steel Co. of America, Pa (f,g,h)
Triangle Conduit & Cable Co., Inc., NJ (b,k)
Trim Alloys, Inc., Mass (a)
Tube Distributors Co., Inc., NY (c,e,f,g,h)
Tube Methods, Inc., Pa (c,f,g)
Tube Reducing Corp., NJ (f,g,h)
Tube Turns Plastics Inc., Ky (k)
Udylite Corp., Mich (k)
Uniform Tubes, Inc., Pa (a,b,f,g)
Union Steel Corp., NJ (g)
U.S. Rubber Co., Mechanical Goods Div., Ind (k)
U.S. Steel Corp., Pa (g)
U.S. Stoneware Co., NY (k)
U.S. Valve & Mfg. Co., Calif (g)
United Wire & Supply Corp., RI (a,b)
Universal Converting Corp., Mass (a)
Vanamatic Co., Ohio (g)
Van Huffel Tube Corp., Ohio (a,b,g)
Van Pelt Corp., Service Steel Div., Mich (f,g,h)
Viking Copper Tube Co., Ohio (b)
Viplax Products Corp., NJ (k)
Visking Corp., Plastics Div., Ind (k)
Vogt Mfg. Corp., NY (k)
Vulcan Metal Products, Inc., Ala (a)
Vulcan Rail & Construction Co., NY (a,c,g)
Wall Tube & Metal Products Co., Tenn (b,f,g)
Wallace Tube Co., Div. of Wallace Supplies Mfg. Co., (a,b,g)
Wallingford Steel Co., Conn (g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Waterman Industries, Inc., Calif (a,b)
Weiskittel, Harry C. Co., Inc., Md (c)
Welding Apparatus Co., Ill (a,f)
Wells, A.H. & Co., Inc., Conn (b)
Western Felt Works, Ill (l,m)
Westlake Plastics Co., Pa (k,l,m)
Wheatland Tube Co., Pa (g)
Wheeling Steel Corp., Va (g)
White Metal Rolling & Stamping Co., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a,b,f,g,h)
Wolverine Tube Div., Calumet & Hecla, Inc., Mich (a,b,g)
Woolf Aircraft Products, Inc., Mich (a,b,f,g)
World Plastex, NY (k,m)
Yardley Plastics Co., Ohio (k)
Youngstown Mfg., Inc., Ohio (a)
Youngstown Sheet and Tube Co., Ohio (g)
Youngstown Welding & Engineering Co., Ohio (a,f,h)

Tungsten

American Metal Climax, Inc., NY (aa)
American Nickel Alloy Mfg. Corp., NY (w,aa)
Associated Engineering & Mfg. Corp., NJ (o,aa,bb,cc,dd,ff)
Belmont Smelting & Refining Works, NY (aa)
Cleveland Tungsten, Inc., Ohio (aa)
Electro Metallurgical Co., Div. of Union Carbide Corp., NY (aa)
Elmet Div., North American Philips Co. Inc., Me (w,aa,bb,ff)
Fansteel Metallurgical Corp., Ill (n,o,q,v,w,z,aa,bb,cc,dd,ee,ff)—Ad pp 138-39
Fromson Orban Co., Inc., NY (ff)
General Electric Co., Lamp Wire & Phosphors Dept., Ohio (w,aa,bb,cc,dd,ff)
Gibson Electric Co., Pa (aa)
Hardy, Charles, Inc., NY (aa)
Hayden Wire Works, Inc., Mass (ff)
Kinkead Industries, Inc., Ill (o)
Mallory-Schwarzkopf Metals, Inc., NY (o,v,w,z,bb,cc,dd,ee,ff)
Molybdenum Corp. of America, Pa (o,w,z,aa,bb,cc,dd)
Shieldalloy Corp., NJ (aa)
Sylvania Electric Products, Inc., Chemical & Metallurgical Div., Pa (w,aa,bb,ff)
Wah Chang Corp., NY (n,aa,bb,cc,ff)
Westinghouse Electric Corp., Pa (o,q,v,w,z,bb,cc,dd,ee)

Upset Forgings

(see Forgings)

Ureas

Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (x)
American Cyanamid Co., Plastics & Resins Div., NY (p,u)
American Viscose Corp., Pa (y)
Archer-Daniels-Midland Co., Minn (p)
Bakelite Co., Div. of Union Carbide Corp., NY (p,x)
Booty Resineers, Inc., NJ (p)
Borden Co., Chemical Div., NY (p)
Catalin Corp. of America, NY (p,x)
Chemical Process Co., Calif (x)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (u)
Dunnican Asso., NJ (y)
du Pont de Nemours, E.I. & Co., Inc., Del (p)
Farley & Loetscher Mfg. Co., Plastics Div., Iowa (cc)
Gordon Chemicals, Inc., Del (y)
Kurz Kasch, Inc., Ohio (y)
Loven Chemical of California, Calif (p,u)
Luminous Resins, Inc., Ill (y)
Mica Insulator Div., Minnesota Mining & Mfg. Co., NY (bb,cc)
Monsanto Chemical Co., Plastics Div., Mass (p)
Muehlstein, H. & Co., Inc., NY (p,y)
Nopco Chemical Co., NJ (p)
Omni Products Corp., NY (p)
Reichhold Chemicals, Inc., NY (p,x)
Robot Devices, Inc., Va (p,u,y)
Sylvan Plastics, Inc., Pa (y)
Synco Resins, Inc., Conn (p)
Texas Glass Fiber Corp., Tex (y)

Urethane Plastics

Adhesive Products Corp., NY (x)
Allied Chemical Corp., Plastics & Coal Chemicals Div., NY (u)
American Latex Products Corp., Calif
American Rubber Products Corp., Ind (u,cc,dd)
Atlas Mineral Products Co., Pa (u)
Burkart, F. Mfg. Co., Div. of Textron Inc., Mo (u)
Cadillac Plastic & Chemical Co., Mich (x,y,bb,cc,dd)
Chemical Coatings & Engineering Co., Inc., Pa (p,u,x)
Crest Chemical Industries Corp., NY (u)
Dayton Rubber Co., Ohio (p,u,x,y,bb,cc,dd,ee)
Disogrin Industries, Inc., NY (bb,cc)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (u,y)
du Pont de Nemours, E.I. & Co., Inc., Del (u)
du Pont de Nemours, E.I. & Co., Inc., Elastomer Chemicals Div., Del (p)
Electro Chemical Engineering & Mfg. Co., Pa (cc)
Englander Co., Inc., Industrial Products Div., Md (u)
Foamade Industries, Mich (u,x,y,cc,dd)
Foss Mfg. Co., Plastics Div., Id (p)
Fry Plastics Co., Calif (u)
Furane Plastics, Inc., Calif (x,y)
General Plastics Mfg. Co., Wash (u,cc)
General Tire & Rubber Co., Ind (u)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Hadley Bros.-Uhl Co., Mo (u)
Hewitt-Robins, Inc., Conn (u)
Interchemical Corp., Finishes Div., NJ (u)
Isocyanate Products, Inc., Del (p,u)
Loven Chemical of California, Calif (p,u)
Luminous Resins, Inc., Ill (y)
Maloney, F.H. Co., Tex (y)
Mobay Chemical Co., Pa (p,u,x,y)
Nesbitt Industries, Inc., Ill (u)
Nopco Chemical Co., NJ (u,cc)
Peiron Corp., Ill (p,x,y)
Reichhold Chemicals, Inc., NY (u)
Rubber Corp. of America, NY (u)
Russell Reinforced Plastics Corp., NY (u)
Schenectady Varnish Co., Inc., NY (p)
Schwab Plastic Corp., Mich (u)
Sheller Mfg. Corp., Mich (u)
Southern Plastics Co., NC (bb,cc,dd,ee)
Strick Plastics Co., Pa (u)
Thiokol Chemical Corp., NJ (p,u,x,y)
Toyad Corp., Pa (u)
United Shoe Machinery Corp., Mass (t,u)
U.S. Rubber Co., Conn (p,u,x,y)
Witco Chemical Co., Ill (p,u)
Woodall Industries, Inc., Mich (u)
World Plastics, NY (bb,cc,dd,ee)

Urethane Rubber

Adhesive Products Corp., NY (x)
American Latex Products Co., Calif
American Rubber Products Corp., Ind (u,cc,dd)
Brown Rubber Co., Inc., Ind (u)
Castle Rubber Co., Pa (y,bb,cc,dd,ee)
Chemical Coatings & Engineering Co., Inc., Pa (u,y)
Chicago-Allis Mfg. Corp., Allis Rubber Div., Ill (p)
Continental Rubber Works, Pa (bb,cc,dd,ee)
Dayton Rubber Co., Ohio (p,u,x,y,bb,cc,dd,ee)
Disogrin Industries, Inc., NY (bb,cc)
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Del. (p,u)
Electro Chemical Engineering & Mfg. Co., Pa (u)
Faultless Rubber Co., Ohio (u)
Flexible Tubing Corp., Conn (ee)
Foamade Industries, Mich (u,x,y,cc,dd)
General Plastics Mfg. Co., Wash (u,cc)
General Tire & Rubber Co., Chemical Div., Ohio (p)
Hewitt-Robins, Inc., Conn (u)
Isocyanate Products, Inc., Del (p,u)
Maloney, F.H. Co., Tex (x,y)
Mobay Chemical Co., Pa (p,u,x,y)—Ad p 199
Naugatuck Chemical Div., U.S. Rubber Co., Conn (p,u,x)
Parker Seal Div., Parker-Hannifin Corp., Ohio (u)
Peiron Corp., Ill (p,u,x,y)
Quaker Rubber Div., H.K. Porter Co., Pa (u)
Reynolds Chemical Products Co., Mich (p,u,x)—Ad p 216
Rubber Corp. of America, NY (u)
Schwab Plastics Corp., Mich (u)
Sheller Mfg. Corp., Mich (u)
Technical Specialties Co., NY (dd)
Thiokol Chemical Corp., NJ (p,y)
Thombert, Inc., Iowa (bb,cc)
Toyad Corp., Pa (t,u)
U.S. Rubber Co., NY (p)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (p,y,cc)
Western Felt Works, Ill (y,cc,dd,ee)
Witco Chemical Co., Ill (p,u)

Vacuum Formed Parts

(see Moldings, Sheet)

Vacuum Metallizing

(see Metallized Coatings)

Vanadium

American Metal Climax, Inc., NY (o)
American Nickel Alloy Mfg. Corp., NY (w)
Belmont Smelting & Refining Works, Inc., NY (aa)
Chace, W.M. Co., Mich (cc,dd)
Chicago Development Corp., Md (aa)
Electro Metallurgical Co., Div. of Union Carbide Corp., NY (w,z,aa,bb)—Ad p 134
General Plate Div., Metals & Controls Corp., Mass (v)
Hardy, Charles, Inc., NY (aa)
Magnesium Elektron, Inc., NY (w,aa)

Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Shieldalloy Corp., NY (aa)
Vanadium Corp. of America, NY (w)
Westinghouse Electric Corp., Pa (o, q,v,w,z,bb,cc,dd,ee)

Varnishes

(see Organic Coatings)

Vinyls

Adhesive Products Corp., NY (x)
Albany Novelty Mfg. Co., Mass (t)
Albert Pipe Supply Co., Inc., NY (ee)
Alpha Plastics, Inc., NJ (bb,ee)
Alpha Wire Corp., NY (ee)
Amercoat Corp., Calif (cc)
American Agile Corp., Ohio (bb,cc,dd, ee)
American Hard Rubber Co., Div. of Amerace Corp., NJ (bb,cc,dd,ee)—Ad pp 196-7
American Molding Powder & Chemical Co., NY (y)
American Products Mfg. Co., Inc., La (p)
Atlas Mineral Products Co., Pa (bb, cc,dd,ee)
Auburn Plastic Engineering, Ill (cc)
Auburn Plastics, Inc., NY (y,bb,cc,dd, ee)
Automotive Rubber Co., Inc., Mich (u,y,cc)
Bakelite Co., Div. of Union Carbide Corp., NY (p,t,u,y,bb)
Bamberger, Claude P., Inc., NJ (p,y)
Bischoff Chemical Corp., Conn (u)
Blacher, B., NY (t)
Blaco Mfg. Co., Ohio (t)
Blank, Arthur & Co., Inc., Mass (t, cc)
Blossom Mfg. Co., Inc., NY (t,cc)
Borden Chemical Co., Resinite Dept., Calif (t,y,bb,cc,dd,ee)
Brown Rubber Co., Inc., Ind (u)
Byers, A.M. Co., Pa (cc)
Cadillac Plastic & Chemical Co., Mich (t,bb,cc,dd,ee)
Carolina Industrial Plastics Div., Essex Wire Corp., NC (u)
Carroll, J.B. Co., Ill (cc)
Carroll Plastic Compounding Corp., Sub. of Plastiglide Mfg. Corp., Calif (y)
Cary Chemicals, Inc., NJ (p)
Celanese Corp. of America, Plastics Div., NJ (p)—Ad pp 183-86
Chemical Products Corp., RI (x)
Chippewa Plastics, Inc., Wis (ee)
Clad-Rex Corp., Ill (t)
Colonial Art Co., Inc., Mass (cc)
Colonial Plastics Mfg. Co., Ohio (bb, cc,dd)
Colton Chemical Co., Div. of Air Reduction Co., Inc., Ohio (p)
Commercial Plastics & Supply Corp., NY (bb,cc)—Ad p 182
Conneaut Rubber & Plastics Co., Ohio (y,bb,cc,dd)
Cordo Chemical Corp., Conn (y)
Crest Chemical Industries Corp., NY (u)
CrystalX Corp., Pa (t,bb,cc,dd,ee)
Dapol Plastics, Inc., Mass (y)
Davis, Joseph Plastics Co., NJ (t,bb)
Dennis Chemical Co., Mo (y)
Designers Metal Corp., Ill (cc)
Diamond Alkali Co., Ohio (p,y)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Douglas & Sturgess, Calif (y)
Dow Chemical Co., Plastics Div., Mich (p,y)—Ad pp 189,198
Dryden Rubber Div., Sheller Mfg. Corp., Ill (y,ee)
du Pont de Nemours, E.I. & Co., Inc., Polychemicals Div., Del (y,cc)
Dura Flex Co., Calif (t,cc)
Dura Plastics of New York, Inc., NY (cc)
Elastomer Chemical Corp., NJ (y)
Electric Steel Foundry Co., Ore (bb, cc,dd,ee)
Electro Chemical Engineering & Mfg. Co., Pa (t)
Eljay Corp., Md (bb,cc,dd,ee)
Elm Coated Fabrics Co., Inc., NY (t,x)
Escambia Chemical Corp., NY (p)
Fasson Products, Ohio (t)
Federal Adhesives Corp., NY (u,y)
Firestone Plastics Co., Pa (p,s,t,x,cc)
Flexfirm Products, Calif (s)
Flexible Tubing Corp., Conn (ee)
Franklin Glue Co., Ohio (p)
Fry Plastics Co., Calif (cc)
Fuller, H.B. Co., Minn (x)
Fullerton Mfg. Co., Calif (y)
Galigher Co., Utah (bb,cc,dd,ee)
Geauga Industries Co., Ohio (bb,dd)
General Gasket Co., Inc., Conn (cc)
General Plastics Mfg. Co., Wash (bb, cc,dd,ee)
General Tire & Rubber Co., Chemical Div., Ohio (p)
General Tire & Rubber Co., Textileather Div., Ohio (x)
Genesee Laboratory, Inc., NY (ee)
Gering Products, Inc., NJ (y,bb,ee)
Goodrich, B.F. Co., Sponge Products Div., Conn (u)
Goodrich, B.F. Chemical Co., Ohio (p,y)
Goodrich, B.F. Industrial Products Co., Ohio (t,bb,cc,dd,ee)
Goodyear Tire & Rubber Co., Chemical Div., Ohio (p)
Great American Industries Inc., Rubatex Div., Va (u)
H & R Industries, Pa (bb,cc,dd,ee)
Hartwell, H. N. & Son, Inc., Mass (bb,cc,ee)
Haskelite Mfg. Corp., Mich (cc,dd)
Haveg Industries, Inc., Del (bb,cc,ee)
Heil Process Equipment Corp., Ohio (x)
Hydrawlik Co., NJ (bb,dd)
Industrial Plastics Corp., Ind (bb,dd)
Interchemical Corp, NY (u,y)
Interchemical Corp., Finishes Div., NJ (u)
Jet Specialties Co., Inc., Calif (bb, dd,ee)
Jones-Dabney Co., Div. of Devoe & Raynolds Co., Inc. Ky (p)
K S H Plastics, Inc., Mo (bb,cc,dd)
Kaykor Industries, Inc., Div. of Kaye-Tex Mfg. Corp., NJ (t,bb,cc,dd,ee)
Knight, Maurice A., Ohio (cc)
Kuss, R.L. & Co., Inc., Ohio (t)
Laminated Plastex Corp., Ohio (x,cc)
Luminous Resins, Inc., Ill (y)
Maloney, F.H. Co., Tex (y)
Mannesmann-Easton Plastic Products Co., Inc., Pa (bb,ee)
Masland Duraleather Co., Pa (t,cc)
Mayon Plastics, Minn (ee)
Monsanto Chemical Co., Organic Chemicals Div., Mo (p)—Ad p 283
Monsanto Chemical Co., Plastics Div., Mass (p,t,y)
Moore, Samuel & Co., Ohio (ee)
Munray Products Div., Fanner Mfg. Co., Ohio (p,x,y)
Naige Co., Inc., NY (ee)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Starch Products Inc., Structural Products Div., NY (p)
National Tube Div., U. S. Steel Corp., Pa (ee)
Naugatuck Chemical Div., U. S. Rubber Co., Conn (p,t,u,x,y,cc)
New England Tape Co., Inc., Mass (u,y,bb,cc,dd)
Newage Industries, Inc., Pa (ee)
Nixon Nitration Works, NJ (cc)
Omni Products Corp., NY (p,t,y,cc)
Ormond Mfg. Co., Inc., NJ (cc,dd)
O'Sullivan Rubber Corp., Va (cc)
Pawling Rubber Corp., NY (bb,dd,ee)
Perfex Plastics, Inc., Ill (bb,dd,ee)
Permacel-LePage's, Inc., NJ (ee)
Philrus Products Co., NJ (bb,cc,dd,ee)
Plast-Ad Mfg. Co., Inc (cc)
Polo Plastics Co., Wis (t)
Poly Resins, Calif (p)
Premier Thermo Plastics Co., Ky (y)
Pyramid Plastics, Inc., Ill (bb,dd,ee)
Pyrosil, Inc., Ohio (u,ee)
Quelcor, Inc., Pa (t)
Rand Rubber Co., NY (p,t,x)
Raybestos-Manhattan, Inc., Plastic Products Div., Conn (x)
Reichhold Chemicals, Inc., NY (p,x)
Reliance Plastic & Chemical Corp., NJ (bb,dd)
Republic Rubber Div., Lee Rubber & Tire Corp., Ohio (p,ee)
Resistoflex Corp., NJ (bb,cc)
Respro Div., General Tire & Rubber Co. (t,cc)
Reynolds Chemical Products Co., Mich (p,x,y)
Reynolds Metals Co., Va (t)
Rezolin, Inc., Calif (t)
Ross & Roberts, Inc., Conn (t)
Rowland Products, Inc., Conn (bb,dd, ee)
Rubber Corp. of America, NY (p,t,u, y,cc)
Rubber & Plastics Compound Co., Inc., NY (cc)
Russell Mfg. Co., Conn (s)
Saran Lined Pipe Co., Mich (bb,cc,ee)
Schwab Plastic Corp., Mich (u,bb,cc, dd,ee)
Scranton Plastic Laminating Corp., Pa (cc)
Seaman Products, Calif (t,cc)
Seiberling Rubber Co., Plastics Div., Ohio (bb,cc)
Shawinigan Resins Corp., Mass (p)
Sheller Mfg. Corp., Mich (y)
Snyder, M.L. & Son, Inc., Pa (cc,ee)
Snyder Mfg. Co., Inc., Ohio (t,cc)
Southern Plastics Co., SC (bb,cc,dd)
Stockwell Rubber Co., Inc., Pa (y,bb, cc,dd)
Sun Steel Co., Ill (t,cc)
Sunlites Plastics, Inc., Wis (bb,dd,ee)
Superior Plastics, Inc., Ill (bb,dd)
Supplex Co., Div. of Amerace Corp., NJ (y,dd,ee)
Synco Resins, Inc., Conn (p)
Texas Plastic Development Corp., Tex (bb)
Toyad Corp., Pa (u)
United Shoe Machinery Corp., Mass (p,u)
U. S. Rubber Co., NY (p,y)
U. S. Stoneware Co., Ohio (cc,ee)
Varflex Corp., NY (ee)
Visking Corp., Plastics Div., Ind (t)
Vogt Mfg. Corp., NY (bb,dd)
Vulcan Rubber Products Div., Reeves Bros., Inc., NY (dd,ee)
Walsen Consolidated Mercantile Co., NY (t,cc)
Watson-Standard Co., Pa (u,y)
Western Plastics Corp., Neb (bb,dd, ee)
Whitehead Metal Products Co., Inc., NY (cc,ee)
Woodall Industries, Inc., Mich (cc)
World Plastex, NY (bb,cc,dd)
Wyatt's Plastics, Inc., Tex (u,bb,cc, dd,ee)

Vinylidene Chloride

(see Vinyls)

Vulcanized Fibre

Ace Plastic Co., NY (bb,cc)
Baer, N.S. Co., NJ (bb,cc,dd,ee)
Cadillac Plastic & Chemical Co., Mich (bb,cc,dd)
Colonial Kolonite Co., Ill (bb,cc,ee)
Commercial Plastics & Supply Corp., NY (bb,cc)
Continental-Diamond Fibre Corp., Del (bb,cc,dd,ee)
Coyne & Paddock, Inc., NY (cc)
Dobeckmun Co., Div. of Dow Chemical Co., Ohio (x)
Electrofilm, Inc., Calif (t)
Insulation Mfrs. Corp., Ill (bb,cc,dd, ee)
Iten Fibre Co., Ohio (s,bb,cc,dd,ee)
Laminated Plastex Corp., Ohio (x,cc)
National Gasket & Washer Mfg. Co., Inc., NY (bb,cc,dd,ee)
National Vulcanized Fibre Co., Del (bb,cc,dd,ee)—Ad p 225

KEY

MATERIALS

a—Aluminum and its alloys
b—Copper and its alloys
c—Iron and its alloys (except steel)
d—Lead and its alloys
e—Magnesium and its alloys
f—Nickel and its alloys
g—Steels
h—Titanium and its alloys
j—Zinc and its alloys
k—Thermoplastics
l—Thermosetting plastics
m—Elastomers

BASIC FORMS

n—Anodes
o—Bar
p—Base resins, polymers or gums
q—Billets
r—Custom formed parts (incl. specialties)
s—Fibers
t—Film
u—Foams (component materials or products)
v—Foil
w—Ingot
x—Laminating, casting resins
y—Molding compounds
z—Plate
aa—Powder
bb—Rod
cc—Sheet
dd—Strip
ee—Tubing
ff—Wire

Penn Fibre & Specialty Co., Inc., Pa (bb,cc,dd,ee)
Philrus Products Co., NJ (bb,cc,dd, ee)—Ad p 194
Spaulding Fibre Co., Inc., NY (bb,cc,dd,ee)—Ad p 217
Staver Co., Inc., NY (cc,dd)
Taylor Fibre Co., Pa (bb,cc,dd)
Thombert, Inc., Iowa (cc,dd)
Westlake Plastics Co., Pa (bb,cc,dd, ee)
Wilmington Fibre Specialty Co., Del (bb,cc)

Welding Rods and Electrodes

(see Filler Metals)

Weldments

Abalon Precision Mfg. Corp., NY (a,b, c,g)
Acme Precision Products, Inc., Ohio (a,f,g)
Acorn Sheet Metal Mfg. Co., Inc., Ill (g)
Adams, I.G. Metalware Co., Mo (g)
Albert Pipe Supply Co., Inc., Foundation Div., NY (g)
Alco Products, Inc., NY (a,b,f,g)
Allis-Chalmers Mfg. Co., Wis. (a,f,g)
Alloy Products Corp., Wis (a,f,g,h)—Ad p 348
Almco Steel Products Corp., Ind (a,b, c,g)
Alten Foundry & Machine Works, Inc., Ohio (g)
Aluminum Co. of America, Pa (a)
Amalgamated Steel Corp., Ohio (g)
American Brake Shoe Co., NY (b)
American Car & Foundry Div., ACF Industries, Inc., NY (a,e,g)
American Cast Iron Pipe Co., Ala (g)
American Machine & Foundry Co., Cleveland Welding Div., Ohio (a,c, f,g,h)
American Metal Products Co., Mich (a,g)
American Pipe & Construction Co., Ore (a,g)
American Sheet Metal Works, Inc., Conn (a,g)
American Welding and Mfg. Co., Ohio (a,f,g,h)
Ampco Metal, Inc., Wis (b)
Anderson, O.L. Co., Inc., Mich (a,b,c, d,g)
Armor Metal Products Co., Ohio (a,g)
Atlas Steel Construction Co., NY (a, b,c,g)
Automotive Rubber Co., Inc., Mich (a, c,e,g)
Baldwin-Lima-Hamilton Corp., Pa (a, g)
Barclay Mfg. Co., Ind (c)
Beatty Machine & Mfg. Co., Ind (g)
Behringer Metal Works, Inc., NJ (a,g)
Beloit Iron Works, Wis (c,g)
Bergen Point Iron Works, NY (a,b,c,f, g,h,j)
Bethlehem Steel Co., Pa (c,g)
Biersach & Niedermeyer Co., Wis (a, b,c,g)
Blaw-Knox Co., Pa (a,g)
Blickman, S. Inc., NJ (a,b,c,f,h)
Bossert Div., Rockwell Spring and Axle Co., NY (a,c,g)
Brandt, Charles T Inc., Md (a,b,e, f,g)
Brinkerhoff Brass & Bronze Works, Inc., NY (a,b,c,f,g)
Brooks & Perkins, Inc., Mich (a,e,g,h)—Ad p 362
Burkhardt Steel Co., Colo (c,g)
Butler Mfg. Co., Mo (a,g)
Caldwell, W.E. Co., Ky (a,g)
Central Fabricators, Inc., Ohio (a,b, c,f,g,h)
Chase Brass & Copper Co., Conn (b)
Clarksville Foundry & Machine Works, Tenn (a,c)
Cleveland Steel Specialty Co., Ohio (g)
Combined Industries Co., NY (a,b,c, e,f)
Combustion Engineering, Inc., Ill (a, b,g)
Commercial Shearing & Stamping Co., Ohio (g)
Composite Forgings, Inc., Mich (g)
Continental Copper & Steel Industries Inc., NY (a,b,c,e,f,g,h)
Cornell and Underhill, Inc., NJ (a,g)
Darby Corp., Kan (a,f,g)
Dare Products, Inc., Mich (g)
Day Co., Minn (a,g)
Dixie Bronze Co., Ala (b)
Dolin Metal Products, Inc., NY (g)
Dow Chemical Co., Magnesium Div., Mich (e)
Downington Iron Works, Pa (c,g)
Dravo Corp., Pa (a,g)
Dresser Mfg. Div., Dresser Industries, Inc., Pa (g)
Electric Auto-Lite Co., Champlain & Mulberry Sts., Ohio (g)
Electric Steel Foundry Co., Ore (g)
Emerson-Sack-Warner Corp., Mass (a, f,g)
Enterprise Wheel & Car Corp., Va (a, g)
Everard Tap & Die Corp., NY (b)
Falk Corp., Wis (g)
Falstrom Co., NJ (a,b,c,d,e,f,g,h,j)
Farwell Metal Fabricating, Minn (a,c, e,g)
Fitzgibbons Boiler Co., Inc., NY (c)
Foster Wheeler Corp., NY (a,f,g)
Gary Steel Products Corp., Va (a,g)
General Alloys Co., Mass (b,f)
General American Transportation Corp., Plate & Welding Div., Ill. (a,f,g)
General Cable Corp., NY (g)
Glasby, J.P. Mfg. Co., Inc., NJ (a,e, g)
Goslin Birmingham Mfg. Co., Inc., Ala (b,f,g)
Graver Tank & Mfg. Co., Inc., Ind (a,f,g)
Greene, G.G. Corp., Pa (g)
Hardy, Mfg. Corp., Ind (g)
Hazledine, E.T. Co., Ind (g)
Hibben & Co., Ill (a,g)
Hicks Corp., Mass (a,b,g)
Hobbs, Clinton E. Co., Mass (c,g)
Houston Blow Pipe & Sheet Metal Works, Tex (a,b,g)
Ideal Can Co., Mass (a,c,g)
Indus Corp., Ind (a,g)
Industrial Equipment Co., Ohio (a,g)
Industrial Pipe & Supply Co., Ill (g)
Industrial Precision Products, Ill (a, c)
Ingalls Iron Works Co., Ala (c,g)
Ingersoll Products Div., Borg-Warner Corp., Ill (g)
Inland Mfg. Co., Neb (g)
Interlake Mfg. Co., Mich (g)
International Nickel Co., Inc., NY (f)
Irvington Form & Tank Corp., NY (a, b,g)
Irwin Foundry and Mine Car Co., Pa (g)
K-D Mfg. Co., Tex (c,g)
Kaiser Steel Corp., Calif (g)
Kewaunee Engineering Corp., Wis (c)
King, Alfred B. Co., Conn (a,b,c,d,f,g)
Koven, L.O. & Bro., Inc., NJ (a,g)
Krueger Fabricating Co., Inc., Wis (a, b,c,e,g)
LFM Mfg. Co., Inc., Sub. of Rockwell Mfg. Co., Kan (g)
Langsenkamp, F.H. Co., Ind (a,b)
Larkin Specialty Mfg. Co., Calif (a, b,g)
Lawrence, L. Co., Inc., NJ (a,b,c,e,g, h,j)
Leader Iron Works, Inc., Ill (a,b,c, f,g)
Levinson Steel Co., Pa (g)
Lincoln Steel Corp., Neb (g)
Lockport Steel Fabricators, Inc., Ill (a,f,g)
Loeffler, J.M. Co., Machine & Brass Works, Pa (a,b,c)
Lukens Steel Co., Pa (a,b,e,f,g,h)
Machine Products Corp., Ohio (a,b,c f,g)
Magline, Inc., Mich (a,e)
Magnesium Co. of America, Ind (a,e)
Mahon, R.C. Co., Mich (a,g)
Manganese Steel Forge Co., Pa (g)
Manufacturers & Fabricators, Inc., Ohio (f,g)
Manufacturers Service, Inc., Ohio (a, b,g)
Mayville Metal Products Co., Wis (g)
McGregor-Michigan Corp., Mich (c,f, g)
McLanahan & Stone Corp., Pa (g)
McNally Pittsburg Mfg. Co., Kan (a, c,g)
Midvale-Heppenstall Co., Pa (g)
Midwest Piping Co., Inc., Mich (g)
Missouri Boiler & Sheet Works, Mo (g)
Moore Dry Dock Co., Calif (g)
Morrisville Foundry Co., Inc., Vt (g)
Morse, Fred W. Co., RI (a,b,c,g,j)
Murray, A.B. Co., Inc., NJ (a,b,f,g)
Murray Tube Works Inc., NJ (g)
Narragansett Boiler Works, Inc., RI (g)
National Lead Construction Co., Inc., NJ (d)
National Metal Products Co., Pa (a, c,g)
National Screw & Mfg. Co., Ohio (g)
National Steel & Shipbuilding Corp., Calif (g)
National Tank Co., Okla (a,g)
Nigg Engineering Corp., Calif (a,c,g)
Pabst Engineering Equipment Co., Inc., NJ (a,c,f,g)
Parish Pressed Steel Div., Dana Corp., Pa (g)
Patterson Foundry & Machine Co., Ohio (a,g)
Pennsylvania Engineering Corp., Pa (g)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (g)
Pfaudler Co., NY (a,f,g)
Phoenix Iron & Steel Co., Pa (g)
Portland Co., Me (a,f,g)
Posey Iron Works, Inc., Pa (g)
Pressed Steel Tank Co., Wis (a,f,g)
Progressive Service Co., Mo (g)
Pusey & Jones Corp., Del (a,b,c,e,f,g)
Queen Products Co., Inc., Ky (a,g)
Rankin Forge Co., Pa (c,g)
Republic Steel Corp., Ohio (g)
Reynolds Metals Co., Va (a)
Rockwell - Standard Corp., Stamping Div., NY (a,b,c,f,g,h,j)
Rolock, Inc., Conn (f,g)
Rose Iron Works, Ohio (a,b,c,f,g,h)
Rosedale Foundry & Machine Co., Pa (g)
Sandy Hill Iron & Brass Works, NY (b,g)
Scaife Co., Pa (a,b,c,f,g)
Seattle Boiler Works, Inc., Wash (a, f,g)
Shank Metal Products Co., NY (a,g)
Sherman & Reilly, Inc., Tenn (a,e,f,g)
Shriver, T. & Co., Inc., NJ (a,g)
Sinclair Co., Mass (b,c,g)
Sioux City Foundry & Boiler Co., Iowa (g)
Smith, A.O. Corp., Wis (a,g)
South River Metal Products Co., Inc., NJ (a,e,g)
Southern Car & Mfg. Co., Inc., Ala (a,g)
Southwestern Porcelain Steel Corp., Okla (g)
Spincraft, Inc., Wis (a,f,g)
Spring City Foundry Co., Pa (c)
Spuck Iron & Foundry Co., Mo (g)
Stacey Mfg. Co., Ohio (a,g)
Stainless Metals, Inc., NY (c,f,h)
Standard Steel Sections, Inc., NY (a, c,g)
Star Heel Plate Co., Inc., NJ (g)
Steel, R. & Sons, Inc., NY (g)
Steel Fabricators Co., Ohio (a,c,e,f, g,h)
Stover Steel Tank & Mfg. Co., Ill (d,f,g)
Struthers Wells Corp., NY (a,f,g,h)
Sylvania Electric Products, Inc., Parts Div., Pa (b,c,f,g)
Texas Foundries, Inc., Tex (g)
Thompson Pipe & Steel Co., Colo (a,b,c,d,e,g,h)
Thys Co., Calif (g)
Toledo Stamping & Mfg. Co., Ohio (g)
Torngren, C.W. Co., Inc., Mass (a,b, c,f,g,h)
Trane Co., Wis (g)
Trojan Steel Co., W.Va (g)
Union Iron Works, Wash (g)
Union Tank Car Co., Ill (a,f,g)
United Shoe Machinery Corp., Mass (a,b,c,e,f,g)
U.S. Steel Corp., Oil Well Supply Div., Tex (g)
U.S. Valve & Mfg. Co., Calif (g)
Variety Stamping Corp., Ohio (c,g)
Victor Steel Products Corp., NY (g)
Vulcan Mfg., Ohio (a,b,c,e,f,g,h)
Wal-Mar Corp., Ill (a,c,e,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Warren Brothers Roads Co., Mass (a, c,d,e,f,g,j)
Waterman Industries, Inc., Calif (a, g)
Wellman Engineering Co., Ohio (g)
Werner, R.D. Co., Inc., NY —Ad p 346
West Point Foundry & Machine Co., Ga (c)
Western Foundry & Machine Works, Inc., Kan (g)
Whyte, Oliver Co., Inc., NY (a,c,g)
Wickwire Spencer Steel Div., Colorado Fuel & Iron Corp., NY (a,b,c,f,g)
Wilder Mfg. Co., Inc., Calif (c,g)
Willamette Iron and Steel Co., Ore (f,g)
Wisconsin Centrifugal Foundry, Inc., Wis (b)
Woolf Aircraft Products, Inc., Mich (a,c,g)
Wyatt Metal & Boiler Works, Inc., Tex (a,b,c,e,f,g)
Youngstown Kitchens Div., American Standard Co., Ohio (a,g)
Youngstown Welding & Engineering Co., Ohio (a,f,h)

Wire

Abalon Precision Mfg. Corp., NY (a, b,c,g)
Ace Wire Spring & Form Co., Inc., Pa (g)
Acme Stamping & Mfg. Co., Pa (a, b,g)
Acme Steel Products Div., Acme Steel Co., Ill (g)
Alabama Wire Co., Inc., Ala (a)
Allegheny Ludlum Steel Corp., Pa (g)
All-State Welding Alloys Co., Inc., NY (a,b,e,f,g,j)
Almco Steel Products Corp., Ind (g)
Alofs Mfg. Co., Mich (a,g)
Alpha Wire Corp., NY (b)
Aluminum Co. of America, Pa (a)
American Brass Co., Conn (b)
American Chain & Cable Co., Pa (g)
American Electric Cable Co., Mass (b, c,g)
American Nickel Alloy Mfg. Corp., NY (f)
American Reed Co., Inc., Mass (c)
American Sheet Metal Works, Inc., Conn (a,b,g)

American Smelting & Refining Co., NY (d)
American Steel & Wire Div., U.S. Steel Corp., Ohio (b,g)
Ampco Metal, Inc., Wis (b)
Anchor Drawn Steel Co., Div. of Vanadium-Alloys Steel Co., Pa (g)
Arcos Corp., Pa (a,f)
Armco Steel Corp., Ohio (g)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Athenia Steel Div., National-Standard Co., NJ (g)
Atlantic Bag Co., NY (g)
Atlantic Steel Co., Ga (g)
Belmont Smelting & Refining Works, Inc., NY (d,j)
Bethlehem Steel Co., Pa (c,g)
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., Pa (f)—Ad p 342
Bridgeport Brass Co., Conn (a,b)
Bristol Brass Corp., Conn (b)
Budek & Bock Spring Mfg. Co., Ill (a,b,g)
Cambridge Wire Cloth Co., Md (a,b,c,e,f,g,h)
Carol Cable Co., Div. of Crescent Co., Inc., RI (b)
Carpenter Steel Co., Pa (g)
Chase Brass & Copper Co., Conn (b)
Cincinnati Pump & Mfg. Co., Inc., Ohio (g)
Clendenin Bros., Inc., Md (a,b)
Colonial Alloys Co., Pa (a)
Colonial Steel Div., Vanadium-Alloys Steel Co., Pa (c,g)
Colorado Fuel and Iron Corp., Colo (g)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Comerford Mfg. Co., Inc., Conn (a,b,c,e,f,g,h,j)
Continental Steel Corp., Ind (g)
Copper and Brass Sales, Inc., Mich (a,b,e)
Crown Metal Co., Wis (d)
Crucible Steel Co. of America, Pa (f,g,h)
Crucible Steel Co. of America, Titanium & Vacuum Metal Products Div., Pa (h)
Curtiss-Wright Corp., Metals Processing Div., NY (g)—Ad p 364
Dare Products, Inc., Mich (b,g)
Detroit Steel Corp., Portsmouth Div., Mich (g)
Division Lead Co., Ill (d)
Dow Chemical Co., Magnesium Div., Mich (e)
Driver, Wilbur B. Co., NJ (b,f)
Driver-Harris Co., NJ (f)
Eaton Mfg. Co., Reliance Div., Ohio (a,b,e,g)
Edgcomb Steel & Aluminum Corp., NJ (a,g)
Electric Auto-Lite Co., Ohio (a,b)
Electric Steel Foundry Co., Ore (g)
Electronic Parts Mfg. Co., NJ (b,f)
Elgin National Watch Co., Ill (f)
Empire Metal Co., NY (d)
Erskine Precision Wire Corp., Pa (b,f,g)
Essex Wire Corp., Magnet Wire Div., Ind (b)
Frasse, Peter A. & Co., Inc., NY (a,g)
Froman Orban Co., Inc., NY (a)
General Alloys Co., Mass (a,b,f,g)
General Cable Corp., NY (a,b)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)
Greene, G.G. Corp., Pa (g)
Hawkridge Bros. Co., Mass (a,h)
Hayden Wire Works, Inc., Mass (a,b,c,d,f,g,j)
Hazledine, E.T. Co., Ind (g)
Hi-Grade Alloy Corp., Ill (d)
Hoskins Mfg. Co., Mich (f)
Hudson Wire Co., NY (b)
Indiana Steel & Wire Co., Inc., Ind (g)
Indium Corp. of America, NY (d)
International Nickel Co., Inc., NY (f)
Jarco Metal Products, NY (g)
Jelliff, C.O. Mfg. Corp., Conn (f)
Johnson Steel and Wire Co., Inc., Mass (g)
Jones & Laughlin Steel Corp., Pa (g)
Kaiser Aluminum & Chemical Sales, Inc., Ill (a)
Kanthal Corp., Conn (c,f)
Keystone Steel & Wire Co., Ill (g)
Laclede Steel Co., Mo (g)
Langsenkamp, F.H. Co., Ind (b)
La Salle Steel Co., Mo (g)
Leach & Garner Co., Mass (b,f)
Lincoln Steel Corp., Neb (g)
Little Falls Alloys, Inc., NJ (a,b,h)
Macwhyte Co., Wis (g)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Mallory - Sharon Titanium Corp., Ohio (h)
Manganese Steel Forge Co., Pa (g)
Matthiessen & Hegeler Zinc Co., Ill (j)
Meico Wire Products, Calif (a)
Metal Goods Corp., Mo (a,b,f)
Metallizing Co. of Los Angeles, Inc., Calif (a,b,c,d,f,g,j)
Mid-States Steel & Wire Co., Ind (g)
Mid-West Wire Products Co., Inc., Mich (g)
National Electric Products Corp., Pa (a)
National Lead Co., NY (d,h)
National Lock Washer Co., NJ (g)
National Standard Div., National-Standard Co., Mich (g)
National-Standard Co., Mich (a,g,h)
Nesor Alloy Products Co., NJ (a,b,c,d,f,g,j)
New England Electrical Works, Inc., NH (b)
Nichols Wire & Aluminum Co., Iowa (a)
Northwestern Steel & Wire Co., Ill (g)
Olin Mathieson Chemical Corp., Aluminum Div., NY (a)
Page Steel & Wire Div., American Chain & Cable Co., Inc., Pa (g)
Parker Metal Goods Co., Mass (a,b,c,g)
Philadelphia Steel & Wire Corp., Pa (g)
Pittsburgh Steel Co., Pa (g)
Republic Steel Corp., Ohio (g)
Reynolds Metals Co., Va (a)
Riverside-Alloy Metal Div., H. K. Porter Co., Inc., NJ (b,f,g)
Roebling's, John A. Sons Corp. NJ (a,b,g)
Rolled Alloys, Inc., Mich (f)
Rolock, Inc., Conn (f)
Ryerson, Joseph T. & Son, Inc., Ill (a,g)
Sandvik Steel, Inc., NJ (g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b)
Seneca Wire & Mfg. Co., Ohio (g)
Sharpsville Steel Fabricators, Inc., Pa (g)
Sherman & Reilly, Inc., Tenn (g)
Simonsen Metal Products Co., Ill (a)
South River Metal Products Co., Inc., NJ (a)
Southern Metal Products Co., La (g)
Standard Metals Corp., Mass (b,f)
Star Heel Plate Co., Inc., NJ (a,b,g)
Stulz-Sickles Co., NJ (g)
Surprenant Mfg. Co., Mass (b)
Sylvania Electric Products, Inc., Parts Div., Pa (b,c,f,g)—Ad p 349
Techalloy Co., Inc., Pa (f,g,h)
Titan Metal Mfg. Co., Pa (b)
Triangle Conduit & Cable Co., Inc., NJ (a,b)
Tyler, W.S. Co., Ohio (a,b,f,g)
U.S. Steel Corp., Pa (g)
United Wire & Supply Corp., RI (a,b)
Uniworld Research Corp. of America, Ohio (c)
Utility Mfg. Co., Mass (a,b,g)
Vanadium-Alloys Steel Co., Pa (c,g)
Wal-Mar Corp., Ill (a,b,c,e,g)
Washburn Wire Corp., Phillipsdale Div., RI (g)
Washington Mfg. Co., Inc., Iowa (g)
Wesco Spring Co., Ill (g)
White Metal Rolling & Stamping Co., NY (a,e)
Whitehead Metal Products Co., Inc., NY (a,b,f,g)
Whyte, Oliver Co., Inc., NY (a,g)
Wickwire Brothers, Inc., NY (g)
Wilson Steel & Wire Co., Ill (g)
Worcester Wire Works Div., National-Standard Co., Mass (g,h)
Youngstown Sheet and Tube Co., Ohio (g)

Wire Cloth

(incl. parts)

Alabama Wire Co., Inc., Ala (a)
American Brass Co., Sub. of Anaconda Co., NY (b)
American Sheet Metal Works, Inc., Conn (a,b,g)
Biersach & Niedermeyer Co., Wis (a,g)
Buffalo Wire Works Co., Inc., NY (a,b,c,f,g)
Cambridge Wire Cloth Co., Md (a,b,c,d,f,g,h,j)
Cleveland Wire Cloth & Mfg. Co., Ohio (a,b,c,f,g,h,j)
Cole-Roscoe Mfg. Co., Conn (b,f)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Electric Steel Foundry Co., Ore (g)
General Alloys Co., Mass (f)
General Cable Corp., NY (a,b)
Gilbert & Bennett Mfg. Co., Conn (a,g)
Green Bay Foundry & Machine Works, Wis (b,f)
Jelliff, C.O. Mfg. Corp., Conn (a,b,c,f,g)
Johnston & Funk Titanium Corp., Ohio (g,h)
Kenmore Machine Products, Inc., NY (f)
Manganese Steel Forge Co., Pa (a,b,c,f)
Metal Goods Corp., Mo (g)
Michigan Wire Cloth Co., Mich (a,b,f,g)
Mid-States Steel & Wire Co., Ind (g)
National-Standard Co., Mich (a,b,c,f,g,h)
Newark Wire Cloth Co., NJ (a,b,c,f,g,h)
Pequot Wire Cloth Co., Div. of Hudson Wire Co., Conn (a,b,f,g)
Reynolds Wire Div., National-Standard Co., Ill (a,b,c,d,f,g,h,j)
Rolock, Inc., Conn (a,b,f,g)
Rotometals, Calif (a,f)
Sherman & Reilly, Inc., Tenn (g)
Star Heel Plate Co., Inc., NJ (g)
Star Wire Screen & Iron Works, Inc., Calif (a,b,c,f,g)
Tyler, W.S. Co., Ohio (a,b,c,f,g)
Uniworld Research Corp. of America, Ohio (c)
Wesbar Stamping Corp., Wis (c,g)
Whitehead Metal Products Co., Inc., NY (a,b,f)
Wickwire Bros., Inc., NY (a,b,g)
Wright, G.F. Steel & Wire Co., Mass (a,b,f,g)

Wire Forms and Parts

(except cloth)

Abalon Precision Mfg. Corp., NY (a,b,c,g)
Ace Wire Spring & Form Co., Inc., Pa (g)
Acme Stamping & Mfg. Co., Pa. (a,b,g)
All-Form Metal Products Co., Ohio (a,b,c,f,g)
Alox Mfg. Co., Mo (a,b,c,f,g)
Aluminum Co. of America, Pa (a)
American Mfg. Co., Tenn (a,g)
American Reed Co., Inc., Mass (c)
American Steel & Wire Div., U.S. Steel Corp., Ohio (g)
Anthes Force Oiler Co., Iowa (g)
Armco Steel Corp., Ohio (g)
Art Wire & Stamping Co., NJ (a,b,c,e,f,g,h,j)
Associated Spring Corp., Wallace Barnes Steel Div., Conn (g)
Automotive Rubber Co., Inc., Mich (f,g)
Bethlehem Steel Co., Pa (c,g)
Blacher Bros., Inc., RI (b,g)
Blaco Mfg. Co., Ohio (g)
Budek & Bock Spring Mfg. Co., Ill (a,b,g)
Buffalo Wire Works Co., NY (a,b,f,g)
Cambridge Wire Cloth Co., Md (a,b,f,g)
Carpenter Steel Co., Pa (g)
Cartwright, R. Tube Products Co., Mich (b)
Cincinnati Pump & Mfg. Co., Inc., Ohio (g)
Clendenin Bros. Inc., Md (a,b,g)
Cleveland Metal Products Co., Ohio (a,b,f,g)
Cleveland Wire Spring Co., Mo (g)
Colorado Fuel and Iron Corp., Colo (g)
Colorado Fuel & Iron Corp., Pacific Coast Div., Calif (g)
Columbus Dental Mfg. Co., Ohio (g)
Comerford Mfg. Co., Inc., Conn (a,b,c,e,f,g)
Dare Products, Inc., Mich (g)
Eastern Tool & Mfg. Co., NJ (a,b,g)
Electronic Parts Mfg. Co., Inc., NJ (b,f)
Elgin National Watch Co., Ill (f)
Empire Spring Co., Ohio (g)
Farwell Metal Fabricating, Minn (a,b,c,e,f,g)
Figley Die & Stamping Co., Ohio (g)
Fryling Mfg. Co., Pa (a,b,c,g)
General Alloys Co., Mass (a,b,f,g)
General Cable Corp., NY (a)
General Findings & Supply Co., Industrial Div., Mass (a,b,c,f,g)

Letters in ( ) indicate materials and forms—see key previous page

Grammes, L.F. & Sons, Inc., Pa (a, b,g)
Greene, G.G. Corp., Pa (g)
Hayden Wire Works, Inc., Mass (g)
Hodges, William & Co., Inc., Pa (g)
Hunter Spring Co., Pa (g)
Industrial Precision Products, Ill (a, b,c,e,f,g,h,j)
Irvington Form & Tank Corp., NY (g)
Judd Industries, Inc., Ohio (a,g)
King Laboratories, Inc., NY (a,f,g)
Laclede Steel Co., Mo (g)
Larkin Specialty Mfg. Co., Calif (a, b,f,g)
Leach & Garner Co., Industrial Div., Mass (a,b,f)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,b,e,g)
Meico Wire Products, Calif (a)
Metal Textile Corp., NJ (a,b,f,g)
Michigan Wire Cloth Co., Mich (a,b, f,g)
Mid-West Wire Products Co., Inc., Mich (g)
Morse, Fred W. Co., RI (a,b,g)
Newark Wire Cloth Co., NJ (a,b,f,g)
Northwestern Steel & Wire Co., Ill (g)
Ormond Mfg. Co., Inc., NJ (a,b,c,f, g,h)
Parker Metal Goods Co., Mass (a,b,c, g)
Penrod, Floyd & Sons Tool & Engineering Corp., Ind (g)
Pittsburgh Steel Co., Pa (g)
Reliable Spring & Wire Forms Co., Ohio (a,b,e,f)
Republic Steel Corp., Ohio (g)
Reynolds Wire Div., National-Standard Co., Ill (a,b,e,f)
Riverside-Alloy Metal Div., H. K. Porter Co., Inc., NJ (b,f,g)
Robertson Steel & Iron Co., Ohio (a, b,g)
Rockford Bolt & Steel Co., Ill (g)
Roebling's, John A. Sons Corp., NJ (g)
Rolock Inc., Conn (a,b,f,g)
Scovill Mfg. Co., Mill Products Div., Conn (a,b,c,f,g)
Servwell Products Co., Ohio (f)
Simonsen Metal Products Co., Ill (a)
Star Heel Plate Co., Inc., NJ (g)
Steel Heddle Mfg. Co., Pa (a,b,c,e,f, g)
Sylvania Electric Products, Inc, Parts Div., Pa (a,b,c,d,f,g)
Titchener, E.H. & Co., NY (a)
Turner & Seymour Mfg. Co., Conn (a, b,g)
Wal-Mar Corp., Ill (a,b,c,g)
Ward, H.H. Co., Pa (a,b,c,f,g,j)
Waterbury Buckle Co., Conn (a,b,g)
Wesco Spring Co., Ill (g)
Whyte, Oliver Co., Inc., Mass (g)
Wilder Mfg. Co., Inc., Calif (a,b,g)
Wire and Iron Products, Inc., Mich (a,b,c,f,g)
Wood, John Co., Minn (g)
Worth Co., Wis (a,b,e,g)

Wood—Balsa

Balsa Equador Lumber Corp., NY
Bogert & Hopper, Inc., NY
Emery, George D. Co., NY
General Veneer Mfg. Co., Calif
International Balsa Corp., NJ
Luthi, F. C. & Co., La
Monteath, J.H. Co., NY
Pollack, Robert Co., Calif
Sterling Models, Pa
Testor Chemical Co., Ill

Wood—Composition Board

Allied Chemical Corp., Plastic & Coal Chemicals Div., NY
Artyle Industries, Inc., Ohio
Balsa Equador Lumber Corp., NY
Gamble Brothers, Inc., Special Products Div., Ky
Georgia-Pacific Corp., Ore
Hardboard Div., Evans Products Co., Ore
Long-Bell Div., International Paper Co., Wash
Masonite Corp., Ill
National Starch Products, Inc., Structural Products Div., NY
Reynolds Aluminum Supply Co., Ga
Roddis Plywood Corp., Wis
U. S. Gypsum Co., Ill
Wal-Mar Corp., Ill
Weyerhaeuser Sales Co., Special Products Div., Wash

Wood—Impregnated and/or Compressed

Everlite Corp., Wash
Fibron Products, Inc., NY
Formica Corp., Sub. of American Cyanamid Co., Ohio
Gamble Brothers, Inc., Special Products Div., Ky
Georgia-Pacific Corp., Ore
Hardboard Div., Evans Products Co., Ore
Micarta Div., Westinghouse Electric Corp., SC
Parkwood Laminates, Inc., Mass
Technical Plywood Sales, Ill
Weyerhaeuser Sales Co., Special Products Div., Wash
Wood Conversion Co., Minn

Wood—Lignum Vitae

Lignum-Vitae Products Corp., NJ

Wood—Plywood

American Plywood Div., Curtis Cos., Inc., Wis
Artyle Industries, Inc., Ohio
Balsa Equador Lumber Corp., NY
Darlington Veneer Co., SC
Delta Plywood Corp., Ark
Gamble Brothers, Inc., Ky
Georgia-Pacific Corp., Ore
Long-Bell Div., International Paper Co., Wash
Nu-Ply Corp., Minn
Pilgrim Plywood Corp., Vt
Puget Sound Plywood, Inc., Wash
Reynolds Aluminum Supply Co., Ga
Roddis Plywood Corp., Wis
Technical Plywood Sales, Ill
Timber Products Co., Ore
U. S. Plywood Corp., NY

Wool Felts

(see Felts)

Wrought Iron

(see Iron)

Zinc and Its Alloys

A & A Die Casting Co., Calif (q)
Advance Stamping Co., Mich (dd)
Alpha Metals, Inc., NJ (v)
American Metal Climax, Inc., NY (o,w)
American Nickel Alloy Mfg. Corp., NY (q,w)
American Sheet Metal Works, Inc., Conn (cc)
American Silver Co., NY (v,dd)
American Smelting & Refining Co., NY (n,v,w)
American Zinc Sales Co., Mo (n,o, q,w,z,cc)
Anchor Metal Co., Inc., NY (w)
Apex Smelting Co., Ill (w)
Belmont Smelting & Refining Works, Inc., NY (n,o,v,w,z,aa,bb,cc,dd,ff)—Ad p 130
Bunker Hill Co., Calif (n,o,cc,dd)
Cerro de Pasco Sales Corp., NY (w)
Chicago Smelting & Refining Corp., Ill (w)
Clark Perforating Co., Mich (cc)
Crown Non-Ferrous Foundry, Inc., Pa (w)
Dahlin, C.A. Co., Ill (cc,ee)
Dixon Sintaloy, Inc., Conn (o)
Duane Specialties, Ltd., NJ (w)
Eagle-Picher Co., Ohio (g,aa)
Empire Metal Co., NY (n,o,q,v,w,z, bb,cc,dd,ff)
Fox Products Co., Pa (n)
General Smelting Co., Pa (n,w,aa)
Hardy, Charles, Inc., NY (aa)
Harshaw Chemical Co., Ohio (n)
Hayden Wire Works, Inc., Mass (ff)
Hi-Grade Alloy Corp., Ill (n,o)
Hodgson Foundry Co., Ill (n)
Hull, R.O. & Co., Inc., Ohio (n)
Illinois Smelting & Refining Co., Ill (o,w,z,aa,bb,cc,dd)
Illinois Zinc Co., Div. of Hydrometals, Inc., Ill (w,z,bb,cc,dd)
Jordan Co., Ill (w)
Kirk, Morris P. & Son, Calif (n)
Lavin, R. & Sons, Inc., Ill (n,w)
Matthiessen & Hegeler Zinc Co., Ill (n,o,q,v,w,z,aa,bb,cc,dd)
McGean Chemical Co., Ohio (n,aa)
Metallizing Engineering Co., Inc., NY (ff)
Metallizing Co. of Los Angeles, Inc., Calif (ff)
Metals Disintegrating Co., Inc., NJ (aa)
Modern Plating Corp., Ill (n)
National Galvanizing Co., Pa (w)
National Lead Co., NY (n,o,q,w,z,bb, cc,dd,ee)
Nesor Alloy Products Co., NJ (ff)
New England Smelting Works, Inc., Mass (o,w)
New Jersey Metals Co., NJ (n)
New Jersey Zinc Co., NY (n,w,z,aa,dd)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (v,w)
Peerless Alloy Co., Colo (o,w)
Pittsburgh Smelting & Refining Co., Pa (w)
Republic Metals Co., Inc., NY (n,o, w)
Rotometals, Calif (n,o,w,aa,bb,cc,dd,ff)
St. Joseph Lead Co., NY (w)
Sail, George Metals Co., Inc., Pa (n,w)
Security Sash & Screen Co., Mich (cc)
Seymour Mfg. Co., Conn (n)
Stevens, Frederic B., Inc., Mich (n)
Udylite Corp., Mich (n)
U. S. Reduction Co., Ind (w)
U. S. Smelting, Refining & Mining Co. NY (w)
Wall Colmonoy Corp., Mich (aa)
White Metal Rolling & Stamping Co., NY (o,bb,ff)

Zirconium and Its Alloys

Allegheny Ludlum Steel Corp., Pa (o,q,v,w,z,bb,cc,dd,ee,ff)
Alloy Tube Div., Carpenter Steel Co., NY (ee)
American Silver Co., NY (v,dd)
Babcock & Wilcox Co., Tubular Products Div., Pa (ee)
Belmont Smelting & Refining Works, Inc., NY (aa)
Bridgeport Brass Co., Conn (o,bb,ee)
Carborundum Co., NY (w)
Carborundum Metals Co., NY (o,q,v, w,z,bb,cc,dd,ee,ff)
Chase Brass & Copper Co., Conn (o, bb)
Columbia National Corp., Mass (w)
Damascus Tube Co., Pa (ee)—Ad p 351
Electric Steel Foundry Co., Ore (o, q,w,bb,ee)
Firth Sterling Inc., Pa (o,q,w,bb,dd)
Foote Mineral Co., Pa (o,v,aa,bb,cc, ff)
Hamilton Watch Co., Precision Metals Div., Pa (v,bb,cc,ff)
Hardy, Charles, Inc., NY (aa)
Harvey Aluminum Div., Harvey Machine Co., Inc., Calif (o,q,w,bb)
Hayden Wire Works, Inc. Mass (aa)
Johnston & Funk Titanium Corp., Ohio (bb,ff)
King Laboratories, Inc., NY (aa)
Makepeace, D.E. Div., Engelhard Industries, Inc., Mass (a,dd,ee,ff)
Mallory-Sharon Metals Corp., Ohio (o,q,v,w,z,bb,cc,dd,ee,ff)
Metal Hydrides, Inc., Mass (aa)
Metallizing Co. of Los Angeles, Inc., Calif (cc,ff)
Metals & Controls Corp., Mass (v,cc, dd,ee,ff)
Michigan Seamless Tube Co., Mich (ee)
National Lead Co., NY (o,q,w,z,bb,cc, dd)
Niagara Falls Smelting & Refining Div., Continental Copper & Steel Industries, Inc., NY (w)
Oregon Metallurgical Corp., Ore (o, q,w)
Republic Steel Corp., Steel & Tubes Div., Ohio (ee)
Superior Steel Corp., Pa (dd)
Superior Tube Co., Pa (ee)
Tube Reducing Corp., NJ (ee)
U. S. Industrial Chemicals Co., Div. National Distillers & Chemical Corp., NY (w)
Wah Chang Corp., NY (w)
Westinghouse Electric Corp., Materials Mfg. Dept., Pa (o,q,w,z,bb,cc, dd,ee)
Zirconium Metals Corp., Sub. of National Lead Co., NY

Addresses of Suppliers ▶

Addresses of Suppliers

a

A & A Die Casting Co., 12901 S Western Ave., Gardena, Calif:

ACF Industries, Inc., 30 Church St., New York 8, N.Y.
American Car & Foundry Div., 750 3d Ave., New York 17, N.Y.

aaRBee Plastic Co., 4505 W Jefferson Blvd., Los Angeles 16, Calif.

Abalon Precision Mfg. Corp., 540 Casanova St., New York 59, N.Y.

Abbott Ball Co., 1074 New Britain Ave., Hartford 10, Conn.

Abbott Products, Inc., 150-50 12th Ave., Whitestone 57, N.Y.

Abco Aluminum & Brass Works, 5235 Griggs Rd., Houston 21, Tex.

Abegg & Reinhold Co., 2533 E 26th St., Los Angeles 58, Calif.

Able Tool & Engineering Co., 865 N Sangamon St., Chicago 22, Ill.

Accurate Brass Corp., 88th St. & 73rd Ave., Glendale, L.I., N.Y.

Accurate Metal Weather Strip Co., Inc., 725 S Fulton Ave., Mt. Vernon, N.Y.

Accurate Molding Corp., 35-20 48th Ave., Long Island City 1, N.Y.

Ace Metal Spinning, 4922 S Western Ave., Chicago 9, Ill.

Ace Plastic Co., 91-30 Van Wyck Expy., Jamaica 35, N.Y.

Ace Wire Spring & Form Co., Inc., Tunnel Way, McKees Rocks, Pa.

Ackermann Mfg. Co., 1134-40 Market St., Wheeling, W. Va.

Acme Aluminum Foundry Co., 6831 S Bell Ave., Chicago, Ill.

Acme Foundry & Machine Co., Coffeyville, Kan.

Acme Foundry & Machine Co., 400 E Erisco, Blackwell, Okla.

Acme Galvanizing Co., 1733 17th St., Oakland 7, Calif.

Acme Mfg. & Gasket Co., 738-40 N 41st St., Philadelphia 4, Pa.

Acme Metal Spinning, Inc., 98 43rd Ave., NE, Minneapolis 21, Minn.

Acme Plating Co., 1563 E 21st St., Cleveland 14, Ohio

Acme Precision Products, Inc., 215 N Findlay St., Dayton 3, Ohio

Acme Resin Corp., 1401 Circle Ave., Forest Park, Ill.

Acme Specialties, Inc., 4326 N American St., Philadelphia 40, Pa.

Acme Stamping & Mfg. Co., 201-209 Corliss St., Pittsburgh 20, Pa.

Acme Steel Co., Acme Steel Products Div., 135th St. & Perry Ave., Chicago 27, Ill.

Acme Steel & Malleable Iron Works, Buffalo 7, N.Y.

Acme Tube, Inc., 212 Coit St., Irvington 11, N.J.

Acme-Newport Steel Co., 9th & Lowell Sts., Newport, Ky.

Acorn Sheet Metal Mfg. Co., Inc., 4605 W 21st St., Chicago 50, Ill.

Acro Metal Stamping Co., 332 E Reservoir, Milwaukee 12, Wis.

Acushnet Process Co., (Ad p 220)
Belleville Ave., New Bedford, Mass.

Adamas Carbide Corp., Market St., Kenilworth, N.J.

Adams Engineering Co., Inc., 19300 Biscayne Blvd., Miami, Fla.

Adams, I. G., Metalware Co., 2947 Delmar Pl., St. Louis, Mo.

Adams Plastic Products, Finlay & Providence Sts., Cincinnati, Ohio

Adhesive Products Corp., 1660 Boone Ave., New York 60, N.Y.

Adirondack Foundries & Steel, Inc., Watervliet, N.Y.

Admiral Corp., Molded Prods. Div., P.O. Box 338, West Chicago, Ill.

Advance Aluminum Castings Corp., 2742 W 36th Place, Chicago 32, Ill.

Advance Foundry Co., 107 Seminary Ave., Dayton, Ohio

Advance Galvanizing Co., 5232 Alcoa Ave., Los Angeles 58, Calif.

Advance Pressure Castings, Inc., 20 Wythe Ave., Brooklyn 11, N.Y.

Advance Screw Products Co., Inc., 3767 S Kinnickinnic Ave., Milwaukee 7, Wis.

Advance Stamping Co., 12025 Dixie Ave., Detroit 39, Mich.

Advance Tool & Die Casting Co., 3760 N Holton St., Milwaukee 12, Wis.

Aelco Foundries, Inc., 1980 S 4th St., Milwaukee 4, Wis.

Aero Screw Co., Inc., Wilmington Rd., Burlington, Wis.

Aerolite Electronics Corp., 507 26th St., Union City, N.J.

Aerolite Extrusion Co., 4605 Lake Park, Youngstown, Ohio

Aetna Felt Co., Inc., 204 Centre St., New York 13, N.Y.

Aetna Steel Co., P.O. Box 2090, Jacksonville 3, Fla.

Affiliated Screw Products Co., 757 W Waveland Ave., Chicago 18, Ill.

Air Reduction Co., Inc., 150 E 42nd St., New York 17, N.Y.
Air Reduction Sales Co., 150 E 42nd St., New York 17, N.Y.
Colton Chemical Co., 1747 Chester Ave., Cleveland 14, Ohio

Aircraft Screw Machine Products Co., 3521 N Halsted St., Chicago 13, Ill.

Akron Standard Mold Co., Lecromelt Casting Div., Houston St., Barberton, Ohio

Alabama Wire Co., Inc., Terrace St., Florence, Ala.

Aladdin Products Co., 26-04 Borough Pl., Woodside 77, N.Y.

Alan Wood Steel Co., Wood Rd., Conshohocken, Pa.

Albany Car Wheel Co., Inc., 185 Broadway, Menends, N.Y.

Albany Novelty Mfg. Co., 107 W Canton St., Boston 18, Mass.

Albany Products Co., Inc., Connecticut Ave., South Norwalk, Conn.

Albert Lea Foundry Co., 910 Marshall Ave., Albert Lea, Minn.

Albert Pipe Supply Co., Inc., 8 Berry St., Brooklyn 11, N.Y.
Foundation Div., 101 Varick Ave., Brooklyn 37, N.Y.

Albion Malleable Iron Co., 601 N Albion St., Albion, Mich.

Albright Son & Co., 123 N Front St., Allentown, Pa.

Alcasco Foundry, 14823 Loomis Ave., Harvey, Ill.

Alco Products, Inc., 30 Church St., New York, N.Y.

Aldan Rubber Co., Tioga & Salmon Sts., Philadelphia 34, Pa.

Alexander Bros. Belting Co., Walnut St. & Princess Ave., Camden 3, N.J.

Alexander, E. P. & Son, Clifton Heights, Pa.

Allegheny Foundry Co., 915 Behan St., Pittsburgh 33, Pa.

Allegheny Ludlum Steel Corp., (Ad p 80)
Oliver Bldg., Pittsburgh 22, Pa.

Allegheny Plastics, Inc., Rt. 51 & Thorn Run Rd., Coraopolis, Pa.

Allen-Stevens Corp., 33-53 62nd St., Woodside 77, N.Y.

All-Form Metal Products Co., 13000 Athens Ave., Cleveland 7, Ohio

Allied Chemical Corp., 61 Broadway, New York 6, N.Y.
General Chemical Div., 40 Rector St., New York 6, N.Y.
Plastics & Coal Chemicals Div., 40 Rector St., New York 6, N.Y.

Solvay Process Div., (Ad p 289)
61 Broadway, New York 6, N.Y.

Allied Machine Products Co., 6174 Concord Ave., Detroit 11, Mich.

Allied Metal Products Co., 81 Prescott St., Worcester 6, Mass.

Allied Products Corp., 12677 Burt Rd., Detroit 23, Mich.

Allied Research Products, Inc., (Ad p 281)
4004 W Monument St., Baltimore 5, Md.

Allied Resinous Products, Inc., Clark & Whitney Sts., Conneaut, Ohio

Allied Steel Castings Co., 1225 W 120th St., Chicago 43, Ill.

Allied Tube Corp., Bristol & Bath Sts., Philadelphia 37, Pa.

Allis-Chalmers Mfg. Co., 501 N 3rd St., La Crosse, Wis.

Allmetal Screw Products Co., Inc., 821 Stewart Ave., Garden City, N.Y.

All-Metals Precision Casting Corp., 22 School St., Yonkers, N.Y.

Alloy Cast Steel Co., Rose Ave., Marion, Ohio

Alloy Metal Powders, Inc., 238 Eagle St., Brooklyn, N.Y.

Alloy Metal Products Inc., 2333 Rockingham Rd., Davenport, Iowa

Alloy Metal Wire Co., Inc., Moore Station, Prospect Park, Pa.

Alloy Precision Castings Co., 3885 W 150th St., Cleveland 11, Ohio

Alloy Products Corp., (Ad p 348)
1045 Perkins Ave., Waukesha, Wis.

Alloy Rods Co., Lincoln Highway W, York, Pa.

Alloy Steel Casting Co., County Line Rd., Southampton, Pa.

Alloy Steel & Metals Co., 1848 E 55th St., Los Angeles 58, Calif.

Alloys & Chemicals Mfg. Co., Inc., 4365 Bradley Rd., SW, Cleveland 9, Ohio

All-State Welding Alloys Co., Inc., 249 Ferris Ave., White Plains, N.Y.

Almco Steel Products Corp., Wabash Ave., Bluffton, Ind.

Almont Mfg. Co., 335 E 3rd St., Imlay City, Mich.

Alofs Mfg. Co., 345 32nd St. SW, Grand Rapids 8, Mich.

Alox Mfg. Co., 6160 Maple Ave., St. Louis 14, Mo.

Alpha Metals, Inc., 56 Water St., Jersey City, N.J.
Alphaloy Corp. Div., 2250 S Lumber St., Chicago, Ill.

Alpha Plastics, Inc., 78 Okner Pkwy., Livingston, N.J.

Alpha Wire Corp., 200 Varick St., New York 14, N.Y

Alpha-Molykote Corp., 65 Harvard Ave., Stamford, Conn.

Alsynite Co. of America, 4654 De Soto St., San Diego 9, Calif.

Alton Foundry & Machine Works, Inc., 226 W Wheeling St., Lancaster, Ohio

Aluminium Ltd. Sales, Inc., 630 5th Ave., New York 20, N.Y.

Aluminum Alloys Corp., 6650 W Walton Ave., Detroit 10, Mich.

Aluminum Billets, Inc., 3786 Oakwood Ave., Youngstown, Ohio

Aluminum Casting & Engineering Co., 2039 S Lenox St., Milwaukee 7, Wis.

Aluminum Co. of America, (Ad p 331)
1501 Alcoa Bldg., Pittsburgh 19, Pa.

Aluminum Extrusions, Inc., 815 Shepherd St., Charlotte, Mich.

Aluminum Finishing Corp., 1012 E 21st St., Indianapolis 2, Ind.

Aluminum Foils Co., P.O. Box 540, Jackson, Tenn.

Aluminum Goods Mfg., Manitowoc, Wis.

Aluminum Industries, Inc., 3670 Werk Rd., Cincinnati, Ohio

Aluminum & Magnesium, Inc., 1 Huron St., Sandusky, Ohio

Aluminum Permanent Mold Co., (Ad p 354)
1054 Front Ave., NW, Grand Rapids 4, Mich.

Aluminum Specialty Co., 17th & Wallmer Sts., Manitowoc, Wis.

Amalgamated Steel Corp., 7835 Broadway Ave., Cleveland 5, Ohio

Ambassador Plastics & Mfg. Corp., 308 W Erie, Chicago 10, Ill.

Ambrit Industries, Inc., 1288 Los Angeles St., Glendale 4, Calif.

Amchem Products, Inc., (Ad p 279)
Ambler, Pa.

Amco Plastic Pipe Co., 2002 Davis St., San Leandro, Calif.

Amerace Corp., American Hard Rubber Co., Supplex Co. Div., 225 North Ave., Garwood, N.J.

Amerace Corp., American

Hard Rubber Co. Div., (Ad pp 196-7)
Ace Rd., Butler, N.J.

Amercoat Corp., 4809 Firestone Blvd., South Gate, Calif.

American Agile Corp., 5461 Dunham Rd., Maple Heights, Ohio

American Aluminum Casting Co., 300 Coit St., Irvington 11, N.J.

American Asbestos Textile Corp., Stanbridge St., Norristown, Pa.

American Brake Shoe Co., 530 5th Ave., New York 36, N.Y.
American Brakeblok Div., 900 W Maple Rd., Troy, Mich.
American Manganese Steel Div., 389 E 14th St., Chicago Heights, Ill.
Amforge Div., 155 N Wacker Dr., Chicago 6, Ill.
Brake Shoe & Castings Div., 230 Park Ave., New York, N.Y.
Electro-Alloys Div., Taylor St. & Abbe Rd., Elyria, Ohio
National Bearing Div., 717 Grant Bldg., Pittsburgh 19, Pa.

American Brass Co., 2114 Meadow, Waterbury 20, Conn.
American Metal-Hose Div., 698 S Main St., Waterbury 20, Conn.

American Cast Iron Pipe Co., (Ad p 329)
2930 16th St. N, Birmingham, Ala.

American Chain & Cable Co., Inc., Reading, Pa.
Acco Steel Casting Div., Tulpehocken St., Reading, Pa.
American Chain Div., 454 E. Princess St., York, Pa.
Page Steel & Wire Div., Box 692, Monessen, Pa.

American Crucible Products Co., (Ad p 136)
1319 Oberlin Ave., Lorain, Ohio

American Cyanamid Co., 30 Rockefeller Plaza, New York 20, N.Y.
Formica Corp. Sub., 4614 Spring Grove Ave., Cincinnati 32, Ohio
Plastics & Resins Div., 30 Rockefeller Plaza, New York 20, N.Y.

American Electric Cable Co., 181 Appleton St., Holyoke, Mass.

American Electrical Products Co., P.O. Box 200, 653 Lida St., Mansfield, Ohio

American Emblem Co., Inc., P.O. Box 116, Utica 1, N.Y.

American Fabricated Products Co., 1420 E 20th St., Indianapolis 7, Ind.

American Felt Co., (Ad p 245)
Glenville, Conn.

American Forge & Mfg. Co., P.O. Box 20, McKees Rocks, Pa.

American Foundries Co., 330 2nd St., Milan, Mich.

American Foundry Co., Inc., 1100 S Fibles Ave., Indianapolis 21, Ind.

American Insulator Corp., (Ad p 358)
New Freedom, Pa.

American Latex Products Corp., 3341 W El Segundo Blvd., Hawthorne, Calif.

American Laundry Machinery Co., Rochester, N.Y.

American Lava Corp., Steatite Div., Cherokee Blvd. & Mfrs. Rd., Chattanooga 5, Tenn.

American Light Alloys, Inc., 1265 McBride Ave., Little Falls, N.J.

American Machine & Foundry Co., W 17th St. & Berea Rd., Cleveland 11, Ohio
Cleveland Welding Div., W 17th St. & Berea Rd., Cleveland 11, Ohio

American Malleable Castings Co., Marion, Ohio

American Manganese Bronze Co., Rhawn & Torresdale Aves., Philadelphia 36, Pa.

American Mannex Corp., Easton Metal Powder Co. Div., 900 Line St., Easton, Pa.

American Mfg. Co., 124 Chestnut, Chattanooga 2, Tenn.

American Metal Climax, Inc., (Ad p 132)
500 5th Ave., New York 36, N.Y.

American Metal Products Co., Linsdale Ave., Detroit 4, Mich.

American Metal Products, Inc., 4500 W Mitchell Ave., Cincinnati 32, Ohio

American Metaseal Corp., 607 65th St., West New York, N.J.

American Molding Co., 2002 Davis St., San Leandro, Calif.

American Molding Powder & Chemical Co., 703 Bedford Ave., Brooklyn 8, N.Y.

American Nickel Alloy Mfg. Corp., 30 Vesey St., New York 7, N.Y.

American Nickeloid Co., 2nd & West Sts., Peru, Ill.

American Pipe & Construction Co., Northwest Div., 518 N E Columbia Blvd., Portland 11, Ore.

American Plastics Corp., 342 Madison Ave., New York 17, N.Y.

American Platinum Works, Newark 5, N.J.

American Potash & Chemical Corp., 3000 W 6th St., Los Angeles 6, Calif.

American Powdered Metals, Inc., 7-9 Philip Pl., North Haven, Conn.

American Products Corp., 422 S Dearborn St., Chicago 5, Ill.

American Products Mfg. Co., Inc., 8127-33 Oleander St., New Orleans 18, La.

American Reed Co., Inc., 2 S Broadway, Lawrence, Mass.

American Reinforced Plastics Co., 12827 E Imperial Hwy., Norwalk, Conn.

American Rubber Products Corp., 315 Brighton St., LaPorte, Ind.

American Sanitary Mfg. Co., Box 111, Abingdon, Ill.

American Screw Co., W Main St., Willimantic, Conn.

American Screw Products Co., 5943 Martin Ave., P. O. Box 96, Detroit 10, Mich.

American Sheet Metal Works, Inc., 16 Jefferson St., Waterbury 20, Conn.

American Silver Co., Inc., 36-07 Prince St., Flushing 54, N.Y.

American Sinteel Corp., 1019 Saw Mill River Rd., Yonkers, N.Y.

American Smelting and Refining Co., Federated Metals Div., 120 Broadway, New York 5, N.Y.

American Solder & Flux Co., 19th & Willard Sts., Philadelphia 40, Pa.

American Stamping Co., 26650 Lakeland Blvd., Cleveland 32, Ohio

American Standard Co., Youngstown Kitchens Div., Ellsworth Ave., Salem, Ohio

American Steel Foundries, Prudential Plaza, Chicago 1, Ill.

American Steel & Pump Corp., Oklahoma Steel Castings Div., 1200 N Peoria Ave., Tulsa, Okla.

American Synthetic Rubber Corp., 500 5th Ave., New York 36, N.Y.

American Tape Co., 4058 Beaufait Ave., Detroit 7, Mich.

American Tinning & Galvanizing Co., 552 W 12th St., Erie, Pa.

American Valve & Enameling Corp., 2855 S Holt Rd., Indianapolis 41, Ind.

American Viscose Corp., 1617 Pennsylvania Blvd., Philadelphia 3, Pa.

American Welding and Mfg. Co., 100 Dietz Rd., Warren, Ohio

American Zinc Sales Co., 1522 Paul Brown Bldg., St. Louis 1, Mo.

American-Marietta Co., 101 E Ontario St., Chicago 11, Ill.

Ames, W. & Co., 417 Communipaw Ave., Jersey City 4, N.J.

Amos-Thompson Corp., Amos Molded Plastics Div., Edinburg, Ind.

Ampco Metal, Inc., 1753 S 38th St., Milwaukee 46, Wis.

Anaconda Co., 25 Broadway, New York 4, N.Y.
American Brass Co., 25 Broadway, New York 4, N.Y.
Anaconda Aluminum Co., 25 Broadway, New York 4, N.Y.
Cochran Foil Co., 25 Broadway, New York 4, N.Y.

Anchor Hocking Glass Corp., Lancaster, Ohio

Anchor Metal Co., Inc., 966 Meeker Ave., Brooklyn 22, N.Y.

Anchor Metal Spinning Co., 46 Fluhart Ave., Dayton 8, Ohio

Anchor Plastics Corp. (Ad p 340)
36-36 36th St., Long Island City 6, N.Y.

Anderson, O.L. Co., Inc., 1347 E Fort St., Detroit 7, Mich.

Anderson Assoc., Inc., 1702 Wayne St., Toledo 1, Ohio

Anderson-Bolling Mfg. Co., Grand Haven, Mich.

Anesite Co., 3575 Touhy Ave., Chicago 45, Ill.

Anthes Force Oiler Co., 20th St. & Ave. M, Fort Madison, Iowa

Anti-Corrosive Metal Products Co., Inc., Castleton-on-Hudson, N.Y.

Apex Foundry, Inc., 633 Lycaste Ave., Detroit 14, Mich.

Apex Smelting Co., 2537 W Taylor St., Chicago 12, Ill.

Apex Steel Corp., Ltd., 6920 E Slauson, Los Angeles 22, Calif.

Apollo Metal Works, 6852 S Oak Park Ave., Chicago, Ill.

Appleton Electric Co., 1701 W Wellington Ave., Chicago 13, Ill.

Applied Instruments, Inc., 25 Will Pl., Brooklyn 7, N.Y.

Approved Mfg. Co., Inc., 307990 W 8th Mile Rd., Farmington, Mich.

Arabol Mfg. Co., 110 E 42nd St., New York 17, N.Y.

Arbonite Corp., 900 N Main St., Doylestown, Pa.

Archer-Daniels-Midland Co., 700 Investors Bldg., Minneapolis, Minn.

Arcos Corp., 1500 S 60th St., Philadelphia 43, Pa.

Ar-Dee Screw Products Co., Inc., 1885 N Clybourn Ave., Worcester 5, Mass.

Ardmore Products, Inc., 194 Atlas Rd., Kenilworth, N.J.

Argosy Products, Inc., 7504 Carnegie Ave., Cleveland 3, Ohio

Aries Laboratories, Inc., 45-33 Davis St., Long Island City 1, N.Y.

Arkansas Foundry Co., 1423 E 6th St., Box 231, Little Rock, Ark.

Armco Steel Corp., 703 Curtis St., Middletown, Ohio
Fabricating Div., Middletown, Ohio
Sheffield Div., Sheffield Sta., Kansas City 25, Mo.

Armet Alloys, Inc., 4338 Bradley Rd., Cleveland 9, Ohio

Armitage, J. L. & Co., 245 Thomas St., Newark, N.J.

Armor Galvanizing Works, Inc., 580 Market St., San Francisco 4, Calif.

Armor Metal Products Co., 3408 Beekman, Cincinnati 23, Ohio

Armour & Co., Adhesive Div., 1355 W 31st St., Chicago, Ill.

Armstrong Cork Co., West Liberty St., Lancaster, Pa.

Armstrong Products Co., P.O. Box 1-MM, Warsaw, Ind.

Arneson Foundry Co., 3303 66th St., Kenosha, Wis.

Arnold Engineering Co., P.O. Box G, Marenge, Ill.

Arrow Metal Products Corp., 3rd Ave., Haskell, N.J.

Arrow Sintered Products Co., 1900 S Kostner Ave., Chicago 23, Ill.

Arrowhead Products, 2300 Curry St., Long Beach 5, Calif.

Art Wire & Stamping Co., (Ad p 330)
227 High St., Newark 2, N.J.

Artex Felt Co., 62 W 39th St., New York 18, N.Y.

Artmor Plastics Corp., 1003 Oldtown Rd., Cumberland, Md.

Artyle Industries, Inc., Box 28, Eaton, Ohio

Arvin Industries, Inc., 13th St., Columbus, Ind.

Arwood Precision Castings Corp., 321 W 44th St., New York 36, N.Y.

Arzt, T. L. Foundry Co., 4020 W Schubert Ave., Chicago 39, Ill.

Asbestos Corp. of America, 31 North Ave., Garwood, N. J.

Asbestos Textile Co., Inc., 165 W Wacker Drive, Chicago 1, Ill.

Asco Sintering Corp., 7799 Telegraph Rd., Los Angeles 22, Calif.

Ashby Mfg. Co., 1601 Woodson Rd., St. Louis 11, Mo.

Asheville-Schoonmaker Mica Co., 900 Jefferson Ave., Newport News, Va.

Ashland Oil & Refining Co., Valvoline Oil Co. Div., 3rd Ave., Freedom, Pa.

Ashtabula Mfg. Co., W 30th St., Ashtabula, Ohio

Associated Engineering & Mfg. Corp., 210 Stonehouse Rd., Glen Ridge, N. J.

Associated Spring Corp., Wallace Barnes Steel Div., (Ad p 81)
18 Main St., Bristol, Conn.

Atlanta Tool Co., 670 Boulevard, NE, Atlanta 5, Ohio

Atlantic Bag Co., 435 S 5th St., Brooklyn 11, N.Y.

Atlantic Brass Works, Inc., 2600 W Addison St., Chicago 18, Ill.

Atlantic Casting Engineering Corp., (Ad p 346)
810 Bloomfield Ave., Clifton, N.J.

Atlantic Foundry Co., 182 Beaver St., Akron 4, Ohio

Atlantic India Rubber Works, Inc., 569 W Polk St., Chicago 7, Ill.

Atlantic Steel Co., P.O. Box 1714, Atlanta 1, Ga.

Atlantic Steel Castings Co., 6th & Lloyd Sts., Chester, Pa.

Atlas Brass Foundry, 1901 Santa Fe Ave., Los Angeles 21, Calif.

Atlas Drop Forge Co., 209 W Mount Hope Ave., Lansing, Mich.

Atlas Foundry Co., 3600 W 69th St., Cleveland 2, Ohio

Atlas Foundry & Machine Co., 3012 S Wilkeson St., Tacoma, Wash.

Atlas Foundry & Mfg. Co., 3701 Collins Ave., Richmond, Calif.

Atlas Galvanizing Co., 2639 Leonis Blvd., Los Angeles 11, Calif.

Atlas Metal Parts Co., 3232 N 31st St., Milwaukee 16, Wis.

Atlas Mineral Products Co., 161 Weber St., Mertztown, Pa.

Atlas Powder Co., Chemicals Div., (Ad p 203)
Wilmington 99, Del.

Atlas Steel Construction Co., 20 Vesey St., New York 7, N.Y.

Auburn Foundry, Inc., W 11th St., Auburn, Ind.

Auburn Mfg. Co., (Ad p 352)
20 Stack St., Middletown, Conn.

Auburn Plastic Engineering, 742 W 79th St., Chicago 20, Ill.

Auburn Plastics, Inc., 48 Canoga St., Auburn, N.Y.

Auburn Rubber Co., Inc., W 11th St., Auburn, Ind.

Auburn Spark Plug Co., Inc., Special

Addresses of Suppliers

Products Div., 89 York St., Auburn, N.Y.
Auel Industries, Herminie, Pa.
Auld, D. L. Co., 5th Ave. & 5th St., Columbus, Ohio
Aurora Metal Co., 614 W Park Ave., Aurora, Ill.
Aurora Refining Co., P.O. Box 88, Aurora, Ill.
Austenal, Inc., 224 E 39th St., New York 16, N.Y.
Autel Electronics Co., Precision Machine & Welding Div., 1122 E St. George Ave., Linden, N.J.
Auto Specialties Mfg. Co., 643 Graves St., St. Joseph, Mich.
Automatic Metal Products Corp., 315-323 Berry St., Detroit 28, Mich.
Automatic Nut Co., Lebanon, Pa.
Automation Corp., Faige Engineering & Mfg. Div., 4733 Elm St., Bethesda 14, Md.
Automotive Rubber Co., Inc., 12594 Beech Rd., Detroit, Mich.
Avco Mfg. Corp., 420 Lexington Ave., New York, N.Y.
American Kitchens Div., 18th & Columbia, Connersville, Ind.
New Idea Div., 420 Lexington Ave., New York, N.Y.
Aviation Developments, Inc., 210 S Victory Blvd., Burbank, Calif.
Avondale Co., 260 Happ Rd., Northfield, Ill.
Avril, G. A. Co., Este Ave. & B&O R.R., Cincinnati, Ohio

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BLC Porous Materials Co., 809 San Antonio Rd., Palo Alto, Calif.
B & T Metals Co., 425 W Town St., Columbus 16, Ohio
Babbitt Chemical Co., Inc., 38 Prospect, New Bedford, Mass.
Babcock & Wilcox Co., Tubular Products Div., Beaver Falls, Pa.
Babson Dow Mfg. Co., 64 Fulda St., Roxbury, Boston 19, Mass.
Backus Novelty Co., 411 Water St., Smethport, Pa.
Bacon Felt Co., 427 W Water St., Taunton, Mass.
Badger Die Casting Corp., 201 W Oklahoma Ave., Milwaukee 7, Wis.
Badger Malleable & Mfg. Co., 223 N Chicago Ave., South Milwaukee, Wis.
Baer, N.S. Co., 1-11 Montgomery St., Hillside 5, N.J.
Baker & Co., Inc., 113 Astor St., Newark 2, N.J.
Balas Collet Mfg. Co., 1557 E 27th St., Cleveland 14, Ohio
Baldwin Mfg. Co., 140 Homer St., Waterbury 20, Conn.
Baldwin-Hill Co., 500 Breunig Ave., Trenton 3, N.J.
Baldwin-Lima-Hamilton Corp., Paschall Sta., Philadelphia, Pa.
Standard Steel Works Div., Burnham, Pa.
Balsa Ecuador Lumber Corp., 502 5th Ave., New York, N.Y.
Bamberger, Claude P. Inc., 1 Mt. Vernon St., Ridgefield Park, N.J.
Banner Iron Works, 1920 S Kingshighway, St. Louis 10, Mo.
Barber Iron Works, Inc., 301 W 61st St., P.O. Box 6318, Shreveport, La.
Barclay Mfg. Co., 1013 S Council St., Muncie, Ind.
Barium Steel Corp., 25 Broad St., New York 4, N.Y.
Barnard Foundry Co., Inc., 9 Roseland St., Springfield 7, Mass.
Barnett Foundry & Machine Co., Irvington, N.J.
Bar-Ray Products, 209 25th St., Brooklyn 32, N.Y.
Barrett Varnish Co., 1532 S 50th Court, Cicero 50, Ill.
Barrows Porcelain Enamel Corp., Langdon Farm Rd. & Penn R.R., Cincinnati 17, Ohio
Bart Mfg. Corp., 227 Main St., Belleville, N.J.
Barth Smelting Corp., 99-129 Chapel St., Newark 5, N.J.
Bartlett-Thompson Co., Inc., 26 Water St., Wakefield, Mass.
Barton Products Corp., P.O. Box 305, West Bend, Wis.
Bassichis Co., 2323 W 3rd St., Cleveland 12, Ohio
Bassons Industries Corp., 1432 W Farms Rd., Bronx 60, N.Y.
Batson-Cook Co., West Point Foundry & Machine Co. Div., West Point, Ga.
Bausch & Lomb Optical Co., 635 St. Paul St., Rochester 2, N.Y.
Baxter Foundry & Machine Works, Inc., P.O. Box 1016, Boise, Id.
Bay City Electric Steel Casting Co., Trumbell St., Bay City, Mich.
Bay City Forge Co., 1802 Cranberry St., Erie, Pa.
Bay City Foundry Co., 400 Webster St., Bay City, Mich.
Bay State Refining Co., Inc., 8 Montgomery St., Chicopee Falls, Mass.
Bay State Stamping Co., 372 Chandler St., Worcester, Mass.
Bay State Tool & Machine Co., 412 Albany, Springfield 4, Mass.
Bayley Products, Inc., 19155 Glendale Ave., Detroit 5, Mich.
Beacon Metal Mfg. Co., 1127 Atlantic Ave., Brooklyn 16, N.Y.
Bead Chain Mfg. Co., 110 Mountain Grove St., Bridgeport 5, Conn.
Bean, Morris & Co., (Ad p 364)
Hyde Rd., Yellow Springs, Ohio
Bearium Metals Corp., 190 Mill St., Rochester, N.Y.
Beatty Machine & Mfg. Co., 940 150th St., Hammond, Ind.
Beaver Valley Alloy Foundry Co., Atlantic Ave., Monaco, Pa.
Beck, I. & Sons, Inc., 256 Mott St., New York 12, N.Y.
Beck Products Corp., 12255 E 8th Mile Rd., Detroit 5, Mich.
Becker Bros. Carbon Co., 3450 S Laramie Ave., Cicero 50, Ill.
Becker, L. A. Foundry Co., 1201 Hwy. 66, St. Louis 15, Mo.
Beckmann, Inc., 120 Baxter St., New York 13, N.Y.
Bee Chemical Co., (Ad p 285)
12933 S Stony Island Ave., Chicago 33, Ill.
Behringer Metal Works, Inc., 108 Jabez St., Newark 5, N.J.
Belcher Malleable Iron Co., Easton, Mass.
Belding Corticelli Industries, 1407 Broadway, New York 18, N.Y.
Belko Corp., Kingsville, Md.
Bell, David Co., Inc., 1555 Fillmore Ave., Buffalo 11, N.Y.
Bellaire Stove Co., 19th & Union Sts., Bellaire, Ohio
Belle City Malleable Iron Co., Racine Steel Castings Div., 1442 Forest St., Racine, Wis.
Belmet Products, Inc., 503 Morgan Ave., New York 22, N.Y.
Belmont Aluminum Extrusion Co., 1228 Belmont Ave., Philadelphia 4, Pa.
Belmont Smelting & Refining Works, (Ad p 130)
330 Belmont Ave., Brooklyn 7, N.Y.
Beloit Foundry Co., 445 Gardner St., South Beloit, Ill.
Beloit Iron Works, Rock River, Beloit, Wis.
Benada Aluminum Products Co., 37 James St., Girard, Ohio
Bendix Aviation Corp., Teterboro, N.J.
Bendix Foundries, Teterboro, N.J.
Benjamin Electric Mfg. Co., Northwest Hwy., Des Plaines, Ill.
Bennett Mfg. Co., 41 Mechanic, Alden, N.Y.
Bergen Point Iron Works, 233 Broadway, New York 7, N.Y.
Bergfels, William & Co., 10 Orchard St., Newark 2, N.J.
Beryl Ores Co., 12900 W 100 Ave., Arvada, Colo.
Beryllium Corp., P.O. Box 1462, Reading, Pa.
National Precision Casting Corp. Div., P.O. Box 396, Paoli, Pa.
Bessemer Galvanizing Works, Bessemer, Ala.
Bethandale Corp., 24040 Lakeland Blvd., Cleveland 23, Ohio
Bethlehem Steel Co., 701 3rd St., Bethlehem, Pa.
Better Finishes & Coatings, Inc., 270 Doremus Ave., Newark, N.J.
Bettinger Corp., Gore St., Waltham, Mass.
Bevan Co., 400 N Arden Dr., El Monte, Calif.
Bickford, F. H., Co., 1529 S Broadway, Dayton 8, Ohio
Biddle Screw Products Co., S Main, Sheridan, Ind.
Bierman-Everett Foundry Co., 133 S 20th St., Irvington 11, N.J.
Biersach & Niedermeyer Co., 1937 N Hubbard St., Milwaukee 12, Wis.
Biggs, Carl H. Co., Inc., 2255 Barry Ave., Los Angeles 64, Calif.
Bignall Co., Main St., Medina, N.Y.
Billings & Spencer Co., 1 Laurel St., Hartford 1, Conn.
Bingham-Herbrand Corp., Herbrand Div., Lake & Stone Sts., Fremont, Ohio
Birchwood Chemical Co., 4500 W. 44th St., Minneapolis 24, Minn.
Birdsboro Steel Foundry & Machine Co., Birdsboro, Pa.
Bischoff Chemical Corp., 120 Main, Ivoryton, Conn.
Bishop, J. & Co. Platinum Works, Stainless Steel Products Div., (Ad p 324)
E King St., Malvern, Pa.
Bishopric Products Co., 4413 Este Ave., Cincinnati 32, Ohio
Bisonite Co., Inc., P.O. Box 84, Kenmore Sta., Buffalo 17, N.Y.
Biwax Corp., 3445 Howard St., Skokie, Ill.
Blacher, B., 752 Broadway, New York 3, N.Y.
Blacher Bros., Inc., 299 Carpenter St., Providence 9, R.I.
Black Bear Co., Inc., 44-45 23rd St., Long Island City 1, N.Y.
Black-Clawson Co., 1700 Grand Ave., Middletown, Ohio
Shartle Div., 2nd & Vine Sts., Hamilton, Ohio
Blackmer Pump Co., Dover, Ohio
Blaco Mfg. Co., 6541 Euclid Ave., Cleveland 8, Ohio
Blakeslee Forging Co., Plant Pl., Plantsville, Conn.
Blank, Arthur & Co., Inc., 33 Causeway St., Boston 14, Mass.
Blaw-Knox Co., 300 6th Ave., Pittsburgh 23, Pa.
Blickman, S., Inc., 536 Gregory Ave., Weehawken, N.J.
Bliss, E. W. Co., Mackintosh-Hemphill Div., 901 Bingham St., Pittsburgh, Pa.
Bliss & Laughlin, Inc., 281 E 155th St., Harvey, Ill.
Blossom Mfg. Co., Inc., 292 Fifth Ave., New York 1, N.Y.
Boatwright Paint & Varnish Works, Inc., P.O. Box 306, Norcross, Ga.
Boehm Screw Products Co., 7100 W Jefferson, Detroit 17, Mich.
Bogert & Hopper, Inc., 105 W 31st St., New York, N.Y.
Bohn Aluminum & Brass Corp., 1400 Lafayette Bldg., Detroit 26, Mich.
Bond, Charles Co., 617-623 Arch St., Philadelphia 6, Pa.
Bond International, Inc., 783 S Deacon, Detroit 17, Mich.
Bone Engineering Corp., 701 W Broadway, Glendale 4, Calif.
Bonnell, William L. Co., Inc. Newman, Ga.
Bonney-Floyd Co., 611 Marion Rd., Columbus 7, Ohio
Bonnot Co., 722 Mulberry Rd., SE, Canton 2, Ohio
Booker & Wallestad, Inc., 3330 Gorham Ave., Minneapolis 26, Minn.
Boonton Molding Co., 326 Myrtle Ave., Boonton, N.J.
Booth Felt Co., Inc., 100 Water St., Brooklyn 1, N.Y.
Boots Aircraft Nut Corp., Newtown Tpke., Norwalk, Conn.
Booty Resineers, Inc., 42 S 3rd St., Newark, N.J.
Borden Co., Chemical Div., 350 Madison Ave., New York 17, N.Y.
Borden Chemical Co., Resinite Dept., 436 E Gutierrez St., Santa Barbara, Calif.
Borg-Warner Corp., 310 S Michigan Ave., Chicago, Ill.
Franklin Steel Div., Franklin, Pa.
Ingersoll Products Div., 1000 W 120th St., Chicago 43, Ill.
Marbon Chemical Div., (Ad pp 210-11)
7165 Chicago Ave., Gary, Ind.
Borkland Mfg. Co., 803 Quarry Rd. at 900 Wabash Rd., Marion, Ind.
Boruski, Ernest F. Jr., 505 5th Ave., New York 17, N.Y.
Bossick Co., Howard Ave., Bridgeport, Conn.
Boston Felt Co., 210 South St., Boston 11, Mass.
Boston Gear Works, 14 Hayward St., Quincy 71, Mass.
Boston Metals Co., Baldt Anchor, Chain & Forge Div., 6th & Butler Sts., Chester, Pa.
Both, A.O. Corp., Nickerson Rd., Ashland, Mass.
Bound Brook Oil-Less Bearing Co., Bound Brook, N.J.
Bowling Green Rubber Co., 4143 Monroe St., Toledo 13, Ohio
Boyles Galvanizing & Plating Co., P.O. Box 187, Hurst, Texas
Bradley Paint Co., 608 W Crawford Ave., Connellsville, Pa.
Bradley & Vrooman Co., 2629 S Dearborn St., Chicago 16, Ill.
Brandt, Charles T. Inc., 1700 Ridgely St., Baltimore 30, Md.
Brasco Mfg. Co., Harvey, Ill.
Brewer-Titchener Corp., 111 Port Watson St., Cortland, N.Y.
Bridgeport Brass Co., 30 Grand St., Bridgeport 2, Conn.
Hunter-Douglas Aluminum Div., 3016 Kansas Ave., Riverside, Calif.
National Cored Forging Div., P.O. Box 119, South Norwalk, Conn.
Bridgeport Moulded Products, Inc., 105 Meadow St., Fairfield, Conn.
Bridgeport Rolling Mills Co., Bridgeport, Conn.
Briel Industries, Inc., 2232 E Market St., New Albany, Ind.

In contacting suppliers, please mention the Materials Selector

Briggs-Shaffner Co., 500 Brookstown Ave., Winston-Salem, N.C.
Brinkerhoff Brass & Bronze Works, Inc., 57½ Dey St., New York 7, N.Y.
Bristol Brass Corp., 580 Broad St., Bristol, Conn.
Broadway Mfg. Co., P.O. Box 252, Springdale Rd., Waukesha, Wis.
Brockway Pressed Metals, Inc., 921 Clark St., Brockway, Pa.
Brom Machine & Foundry Co., 3565 6th St., Winona, Minn.
Bronze & Steel Die Casting Co., Plane, Ill.
Brooks & Perkins, Inc., (Ad p 362)
1950 W Fort St., Detroit 16, Mich.
Brown Corp., 213 Bellevue Ave., Syracuse 1, N.Y.
Brown Rubber Co., Inc., P.O. Box 1000, Lafayette, Ind.
Bruce Foundry & Mfg. Co., 4040 S Evans St., Tecumseh, Mich.
Brush Beryllium Co., (Ad p 130)
4301 Perkins Ave., Cleveland 3, Ohio
Buchmann Spark-Wheel Corp., 4-20 47th Ave., Long Island City 1, N.Y.
Buckeye Brass & Mfg. Co., 6410 Hawthorne Ave., Cleveland 3, Ohio
Buckeye Iron & Brass Works, 324 E 3rd St., Dayton 1, Ohio
Buckeye Molding Co., 213 S 3rd St., Miamisburg, Ohio
Budd-Stanley Co., Inc., 43-01 22nd St., Long Island City 1, N.Y.
Budek & Bock Spring Mfg. Co., 4014 W Grand Ave., Chicago 51, Ill.
Buffalo Steel Corp., Tonawanda, N.Y.
Buffalo Wire Works Co., 320 Terrace, Buffalo 2, N.Y.
Buffalo-Eclipse Corp., Buffalo Bolt Div., 101 East Ave., North Tonawanda, N.Y.
Bullock, W.J. Inc., P.O. Box 539, Fairfield, Ala.
Bundy Tubing Co., 8109 E Jefferson, Detroit 14, Mich.
Bunker Hill Co., Sales & Fabrication Div., 660 Market St., San Francisco 4, Calif.
Bunting Brass & Bronze Co., 715 Spencer, Toledo 1, Ohio
Burgess-Norton Mfg. Co., 737 Peyton St., Geneva, Ill.
Burkhardt Steel Co., 869 S Broadway, Denver 9, Colo.
Burwood Products Co., Airport Dr., Traverse City, Mich.
Busada Mfg. Corp., (Ad p 356)
58-99 54th St., Maspeth 78, N.Y.
Busch, J.C. Co., 17 W 54th St., New York 19, N.Y.
Butler Engine & Foundry Co., Inc., 151 S Monroe, Butler, Pa.
Butler Mfg. Co., 7309 E 13th St., Kansas City, Mo.
Button Corp. of America, 49 Dickerson St., Newark 9, N.J.
Byers, A. M., 1810 Clark Bldg., Pittsburgh 22, Pa.
Byrd Plastics, Inc., 2953 W 12th St., Erie, Pa.

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C. E. M. Co., 3 School St., Danielson, Conn.
C & G Screw Machine Products Co., P.O. Box 308, Carmel, Ind.
Cadillac Malleable Iron Co., 10th St., Cadillac, Mich.
Cadillac Plastic & Chemical Co., 15111 2nd Ave., Detroit, Mich.
Caldwell, W. E. Co., 2020 Brook St., Louisville 8, Ky.
Calfibe Co., Inc., P.O. Box 832, Redlands, Calif.
California Drop Forge Co., 1033 Alhambra Ave., Los Angeles 12, Calif.
California Metal Enameling Co., 6904 E Slauson Ave., Los Angeles 22, Calif.
California Perforated Screen Co., 345-347 Folsom St., San Francisco 5, Calif.
Callahan Zinc-Lead Co., Inc., Flexaust Div., 100 Park Ave., New York 17, N.Y.
Calorizing Co., P.O. Box 8742, Pittsburgh 21, Pa.
Calumet & Hecla, Inc., 11 Calumet Ave., Calumet, Mich.
Calumet Div., 11 Calumet Ave., Calumet, Mich.
Wolverine Tube Div., 1439 Central Ave., Detroit 9, Mich.
Calumet Steel Castings Corp., 1636 Summer St., Hammond, Ind.
Cambridge Wire Cloth Co., Cambridge, Md.
Camcar Screw & Mfg. Co., 600 18th Ave., Rockford, Ill.
Cameron Iron Works, Inc., Special Products Div., (Ad p 339)
P.O. Box 1212, Houston 1, Tex.
Camfield Fiberglass Plastics, Inc., N Centennial St., Zeeland, Mich.
Camloc Fastener Corp., 22 Spring Valley Rd., Paramus, N.J.
Campbell, A.S. Co., Inc., 161 Prescott St., East Boston 28, Mass.
Campro Co., 3131 Alliance Rd., NE, Canton 1, Ohio
Canfield, H.O. Co., Box 529, Clifton Forge, Va.
Cannon-Muskegon Corp., 2875 Lincoln St., Muskegon, Mich.
Canton Malleable Iron Co., 2408 13th NE, Canton, Ohio
Capac Industries, Inc., 309 S Main St., Capac, Mich.
Capitol Chemical Co., 4501 W Haddon Ave., Chicago 51, Ill.
Capitol Products Corp., Mechanicsburg, Pa.
Carbo Tool & Die Co., 219 Howland St., Fremont, Ohio
Carboline Co., 32 Hanley Ct., St. Louis 17, Mo.
Carborundum Co., (Ad p 244)
Niagara Falls, N.Y.
Stupakoff Div., Latrobe, Pa.
Carborundum Metals Co., P.O. Box 32, Akron, N.Y.
Carey, Philip, Mfg. Co., 320 S Wayne Ave., Lockland, Cincinnati 15, Ohio
Carleton Screw Products Co., 2424 Hiawatha Ave S, Minneapolis 4, Minn.
Carlon Products Corp., 10224 Meech Ave., Cleveland 5, Ohio
Carlson, G.O. Inc., Thorndale, Pa.
Carolina Asbestos Co., Davidson, N.C.
Carondelet Foundry Co., 2101 S Kingshighway, St. Louis 10, Mo.
Carpenter Steel Co., 101 W Bern St., Reading, Pa.
Alloy Tube Div., Springfield Rd., Union, N.J.
Carroll, J.B. Co., 319 N Albany Ave., Chicago 12, Ill.
Carroll Pressed Metal, Inc., 133 Dewey St., Worcester 10, Mass.
Cartwright, R. Tube Products Co., 609 St. Jean Ave., Detroit 14, Mich.
Cary Chemicals, Inc., P.O. Box 1128, New Brunswick, N.J.
Case, J. I. Co., 702 State St., Racine, Wis.
Caspers Tin Plate Co., 4100 W 42nd Pl., Chicago 32, Ill.
Cast Optics Corp., (Ad pp 204, 205)
123 Newman St., Hackensack, N.J.
Casting Engineers, Inc., (Ad p 332)
2323 N Bosworth, Chicago, Ill.
Casting Service Corp. of Michigan, Mathien Ave., Bridgman, Mich.
Castle, A. M. & Co., 3400 N Wolf Rd., Franklin Park, Ill.
Castle Rubber Co., P.O. Box 589, Butler, Pa.
Catalin Corp. of America, 1 Park Ave., New York 16, N.Y.
Cayce Corp., 1444 Hamilton Ave., Cleveland 14, Ohio
Cedar Heights Clay Co., 50 Portsmouth Rd., Oak Hill, Ohio
Ceilcote Co., 4832 Ridge Rd., Cleveland 9, Ohio
Celanese Corp. of America, Plastics Div., (Ad pp 183-86)
744 Broad St., Newark 2, N.J.
Celluplastic Corp., 50 Ave. L, Newark 5, N.J.
Central Fabricators, Inc., 408-18 Poplar St., Cincinnati, Ohio
Central Felt & Fabrics Corp., 24 W 25th St., New York 10, N.Y.
Central Screw Co., 3501 S Shields, Chicago 9, Ill.
Central Screw Products Co., 284 Walker St., Detroit 7, Mich.
Centrifugal Casting Co., 147 W 42nd St., New York 36, N.Y.
Centrifugal Casting Machine Co., P.O. Box 947, Tulsa 1, Okla.
Centr-O-Cast & Engineering Co., 45 South St. & St. Jean Ave., Detroit 14, Mich.
Century Die Casting Co., 2629 W Fletcher St., Chicago 18, Ill.
Ceromet, Inc., 16233 Gale Ave., Industry, Calif.
Cerro De Pasco Corp., Lewin-Mathes Div., 1111 Chouteau Ave., St. Louis 2, Mo.
Cerro de Pasco Sales Corp., (Ad p 133)
300 Park Ave., New York 22, N.Y.
Chace, W.M. Co., 1600 Beard Ave., Detroit 9, Mich.
Chain Belt Co., 4701 W Greenfield Ave., Milwaukee 1, Wis.
Chambersburg Engineering Co., Derbyshire St., Chambersburg, Pa.
Champion Rivet Co., (Ad p 398)
Harvard Ave. & E 108th St., Cleveland 5, Ohio
Chandler Products Corp., 1491 Chardon Rd., Cleveland 17, Ohio
Channel Master Corp., Ellenville, N.Y.
Chapman Machine Co., Inc., 41 Main St., Terryville, Conn.
Chardon Metal Products Co., Mill St., Chardon, Ohio
Chardon Rubber Co., 6th & Washington Aves., Chardon, Ohio
Charlotte Leather Belting Co., 209 E 12th St., Charlotte 1, N.C.
Chase Brass & Copper Co., 236 Grand St., Waterbury 91, Conn.
Chattanooga Aluminum Foundry, Inc., 2000 Chestnut St., Chattanooga 8, Tenn.
Chemical Corp., (Ad p 291)
67 Waltham Ave., Springfield 9, Mass.
Chemical Coatings Corp., Dividend Rd., Rocky Hill, Conn.
Chemical Coatings & Engineering Co., Inc., Box 305, Brooke St., Media, Pa.
Chemical Development Corp., Endicott St., Danvers, Mass.
Chemical Process Co., 1901 Spring St., Redwood City, Calif.
Chemical Products Corp., King Philip Rd., Providence 14, R.I.
Chemung Foundry Corp., Elmira, N.Y.
Chicago Aluminum Castings, 2647 Ogden Ave., Chicago, Ill.
Chicago Development Corp., 5810 47th Ave., Riverdale, Md.
Chicago Extruded Metals Co., 1642 S 54th Ave., Cicero 9, Ill.
Chicago Gasket Co,. 1271 W North Ave., Chicago 22, Ill.
Chicago Hardware Foundry Co., 2500 Commonwealth Ave. N, Chicago, Ill.
Chicago Malleable Castings Co., 1225 W 120th St., Chicago 43, Ill.
Chicago Molded Products Corp., 1050 N Kolmar Ave., Chicago 35, Ill.
Campco Div., 2736 N Normandy Ave., Chicago 35, Ill.
Chicago Powdered Metal Products Co., Schiller Park, Ill.
Chicago Rawhide Mfg. Co., (Ad pp 187-88)
1301 Elston Ave., Chicago 22, Ill.
Chicago Rivet & Machine Co., 950 S 25th Ave., Bellwood, Ill.
Chicago Rubber Co., Inc., 651 Market St., Waukegan, Ill.
Chicago Smelting & Refining Corp., 3701 S Kedzie Ave., Chicago 32, Ill.
Chicago Steel Service Co., 4444 S Kildare Ave., Chicago 32, Ill.
Chicago Thrift-Etching Corp., 1555 N Sheffield Ave., Chicago 22, Ill.
Chicago White Metal Casting, Inc., 5239 W Grand Ave., Chicago 39, Ill.
Chicago-Allis Mfg. Corp., Allis Rubber Div., 113-125 N Green St., Chicago 7, Ill.
Chicopee Mills, Inc., 49 Worth St., New York, N.Y
Chippewa Plastics, Inc., 210 W Columbia St., Chippewa Falls, Wis.
Chromalloy Corp., (Ad p 282)
450 Tarrytown Rd., White Plains, N.Y.
Elyria Foundry Div., Elyria, Ohio
Chromium Corp. of America, 100 Park Ave., New York 17, N.Y.
Chrysler Corp., P.O. Box 1687, Detroit 31, Mich.
Amplex Div., P.O. Box 2718, Detroit 31, Mich.
Cycleweld Div., 5437 W Jefferson, Trenton, Mich.
Ciba Co., Inc., 622 Greenwich St., New York 14, N.Y.
Plastics Div., (Ad pp 212-13)
Kimberton, Pa.
Cincinnati Forging Co., 5604 Booster Pike, Cincinnati, Ohio
Cincinnati Foundry Co., 238 W Mitchell Ave., Cincinnati 32, Ohio
Cincinnati Pump & Mfg. Co., Inc., 3182 Beekman St., Cincinnati 23, Ohio
City Plating Works, Inc., 905 Honeyspot Rd., Stratford, Conn.
Clad-Rex Corp., 2101 S Indiana, Chicago 28, Ill.
Clapp, E. D. Mfg. Co., 305 Genesee St., Auburn, N.Y.
Clark Bros. Bolt Co., Milldale, Conn.
Clark Perforating Co., 15875 Allen Rd., Milan, Mich.
Clarksville Foundry & Machine Works, Commerce & Spring Sts., Clarksville, Tenn.
Clayton & Lambert Mfg. Co., 1701 Dixie Hwy., Louisville 10, Ky.
Clayton Mark & Co., 1900 Dempster St., Evanston, Ill.
Clendenin Bros., Inc., 4309 Erdman Ave., Baltimore 13, Md.
Cleveland Cap Screw Co., 4444 Lee Rd., Cleveland 28, Ohio
Cleveland City Forge Co., 1621 Euclid Ave., Cleveland 15, Ohio
Cleveland Electro Metals Co., 2391 W 38th St., Cleveland 13, Ohio
Cleveland Foundry & Mfg. Co., Inc., 685 6th St., NE, Cleveland, Tenn.
Cleveland Graphite Bronze Co., 17044 St. Clair Ave., Cleveland 10, Ohio
Cleveland Hard Facing Co., Inc., 3047 Stillson Ave., Cleveland 5, Ohio
Cleveland Hardware & Forging Co., 3270 E 79th St., Cleveland 4, Ohio

Addresses of Suppliers

Cleveland Metal Products Co., Washington & Center Sts., Cleveland 13, Ohio
Cleveland Porcelain Enameling Co., 3100 E 65th St., Cleveland 27, Ohio
Cleveland Pressed Products Corp., 6712 Union Ave., Cleveland 5, Ohio
Cleveland Steel Specialty Co., Inc., 3765 E 91st St., Cleveland 5, Ohio
Cleveland Tungsten, Inc., 10200 Meech Ave., Cleveland 5, Ohio
Cleveland Wire Cloth & Mfg. Co., 3573 E 78th St., Cleveland 5, Ohio
Cleveland Wire Spring Co., 300 E Main St., De Soto, Mo.
Cliff Mfg. Co., 30240 Lakeland Blvd., Wickliffe, Ohio
Clifton Conduit Co., Inc., 3300 Eastbourne Ave., Baltimore 24, Md.
Clinton Metal Products Co., 1076 W Locust St., Wilmington, Ohio
Clopay Corp., Clopay Sq., Cincinnati 14, Ohio
Closures, Inc., 46 State St., Waterbury, Conn.
Clover Industries, Inc., 572-588 Young St., Tonawanda, N.Y.
Cly-Del Mfg. Co., Inc., Box 1367, Waterbury, Conn.
Coast Mfg. & Supply Co., P.O. Box 71, Livermore, Calif.
Coated Abrasive Products, Inc., 30208 Lakeland Blvd., Wickliffe, Ohio
Coated Coil Corp., 513 W 30th St., New York 1, N.Y.

Coating Products, Inc., (Ad p 291)
101 W Forest Ave., Englewood, N.J.

Cochran Foil Co., 1430 S 13th St., Louisville, Ky.
Cochrane Foundry, Inc., Box 749, York, Pa.
Cohan Epner Co., Inc., 142 W 14th St., New York 11, N.Y.
Cole-Roscoe Mfg. Co., 55 Bates Ct., South Norwalk, Conn.
Collis Co., Clinton, Iowa
Colonial Alloys Co., Ridge Ave. & Crawford St., Philadelphia 29, Pa.
Colonial Art Co., Inc., Crane Ave., Westfield, Mass.
Colonial Kolonite Co., 2232 Armitage Ave., Chicago 47, Ill.
Colonial Plastics Mfg. Co., 2685 E 79th St., Cleveland 4, Ohio
Colonial Rubber Co., 706 Oakwood St., Ravenna, Ohio
Colorado Fuel & Iron Corp., Continental Oil Bldg., Denver 2, Colo.
Pacific Coast Div., 1080 19th Ave., Oakland 6, Calif.
Wickwire Spencer Steel Div., 575 Madison Ave., New York 22, N.Y.
Colt's Plastics Co., Inc., P.O. Box 119, Hartford, Conn.
Columbia Metal Stamping Co., 11900 Harvard Ave., Cleveland 5, Ohio
Columbia Tool Steel Co., Lincoln Hwy. & State St., Chicago Heights, Ill.
Columbian Bronze Corp., 216 Main St., Freeport, N.Y.
Columbian Steel Tank Co., 1509 W 12th St., Kansas City 1, Mo.
Columbiana Pump Co., Columbiana, Ohio
Columbia-National Corp., 70 Memorial Drive, Cambridge, Mass.
Columbus Bolt & Forging Co., 291 Marconi Blvd., Columbus 15, Ohio
Columbus Dental Mfg. Co., 634 Wager St., Columbus 6, Ohio
Columbus Jack Corp., 2200 S Third St., Columbus 7, Ohio
Columbus Production Mfg. Co., 935 W Goodale Blvd., Columbus 8, Ohio
Combined Industries Co., P.O. Drawer 431, Catskill, N.Y.
Combustion Engineering, Inc., 1318 N Branch St., Chicago 22, Ill.
Comerford Mfg. Co., Inc., 81 Farmington Ave., Bristol, Conn.
Comet Metal Products Co., Inc., 9104 132nd St., Richmond Hill 18, N.Y.
Commercial Chemical Co., 1021 Summer St., Cincinnati 4, Ohio
Commercial Iron Works, 2424 Porter, Los Angeles, Calif.
Commercial Plastics Co., Associated Plastic Div., 400 E Hines St., Midland, Mich.

Commercial Plastics & Supply Corp., (Ad p 182)
630 Broadway, New York 12, N.Y.

Commercial Screw Products Co., 15105 Darwin Ave., Cleveland 10, Ohio
Commercial Shearing & Stamping Co., 1775 Logan Ave., Youngstown, Ohio
Commercial Steel Casting Co., Cheney Ave., Marion, Ohio
Commercialores, Inc., Box 98, Clover, S.C.
Compacted Metals Corp., 99 Greenwood Ave., Waukegan, Ill.
Composite Forgings, Inc., 2300 W Jefferson Ave., Detroit 16, Mich.
Compton Foundry, Compton, Calif.
Concord Mica Corp., 26 Crescent, Penacook, N.H.
Condamatic Co., Inc., 2700 E 9 Mile Rd., Hazel Park, Mich.
Conforming Matrix Corp., 12th & Woodruff Sts., Toledo 2, Ohio
Conn Perry Mfg. Co., 4341 Horatio Ave., Detroit 10, Mich.
Conneaut Die Casting Co., 618 Sandusky St., Conneaut, Ohio
Conneaut Rubber & Plastics Co., Commerce St., Conneaut, Ohio

Connecticut Hard Rubber Co., (Ad p 205)
407 East St., New Haven 9, Conn.

Connecticut Malleable Castings Co., New Haven 6, Conn.
Connecticut Mfg. Co., 115 Benedict St., Waterbury 20, Conn.
Connell Asbestos Mfg. Co., 117 Martense St., Brooklyn 26, N.Y.
Conner Mfg. Co., 828 S 17th St., Louisville, Ky.
Consolidated Electrodynamics Corp., Rochester Div., 1775 Mt. Read Blvd., Rochester 3, N.Y.
Consolidated Foundries & Mfg. Corp., Michigan Steel Casting Co. Div., 1999 Guoin St., Detroit 7, Mich.
Consolidated Fruit Jar Co., 62 Water St., P.O. Box 109, New Brunswick, N.J.

Consolidated Molded Products Corp., (Ad p 326)
1940 Thomas St., Scranton, Pa.

Consoweld Corp., 700 Hooker St., Wisconsin Rapids, Wis.
Continental Boiler & Sheet Iron Works, 5603 W Park Ave., St. Louis, Mo.
Continental Can Co., 100 E 42nd St., New York 17, N.Y.
Conolite Div., 205 W 14th St., Wilmington, Del.
Shellmar-Betner Flexible Packaging Div., 100 E 42nd St., New York 17, N.Y.
Continental Copper & Steel Industries, Inc., 345 Madison Ave., New York 17, N.Y.
Niagara Falls Smelting & Refining Div., 2200-2214 Elmwood Ave., Buffalo 23, N.Y.
Continental Die Casting Corp., 9615 Grinnell Ave., Detroit 13, Mich.

Continental Felt Co., (Ad p 250)
26 W 15th St., New York 11, N.Y.

Continental Foundry & Machine Co., 144th & Railroad Ave., East Chicago, Ind.
Continental Gin Co., Birmingham, Ala.
Continental Rubber Works, 1985 Liberty St., Erie 6, Pa.
Continental Screw Co., 459 Mt. Pleasant St., New Bedford, Mass.
Continental Steel Corp., 1109 S Main St., Kokomo, Ind.
Continental Wire & Iron Works, Continental Nu-Steel Metal Products Div., 1249 S Ashland Ave., Chicago 8, Ill.
Continental-Diamond Fibre Corp., Newark, Del.
Continental-Emsco Co., P.O. Box 2098, Terminal Annex, Los Angeles 54, Calif.
Contour Extrusion Co., 517 Fayette Ave., Mamaroneck, N.Y.
Control Parts Corp., 530 Burnside Ave., Inwood 96, L.I., N.Y.
Conversion Chemical Corp., 98 E Main St., Rockville, Conn.
Cooley, W.J. & Co., P.O. Box 1471, 107 Hernando, Memphis, Tenn.

Cooper Alloy Corp., (Ad p 353)
Bloy St. & Ramsey Ave., Hillside 5, N.J.

Cooper, Peter Corp., Palmer St., Gowanda, N.Y.
Cooper-Bessemer Corp., Mt. Vernon, Ohio
Coors Porcelain Co., 600 9th St., Golden, Colo.
Copolymer Rubber and Chemical Corp., P.O. Box 2591, Baton Rouge 1, La.
Copper and Brass Sales, Inc., 6555 E Davison St., Detroit 12, Mich.
Copper Range Co., Hussey, C.G. & Co. Div., 2850 2nd Ave., Pittsburgh 19, Pa.
Copperweld Steel Co., Warren, Ohio
Aristoloy Steel Div., Mahoning Ave. Ext., Warren, Ohio
Ohio Seamless Tube Div., Shelby, Ohio
Superior Steel Div., Hammond & Gregg St., Carnegie, Pa.

Cordo Chemical Corp., (Ad p 394)
34 Smith St., Norwalk, Conn.

Cordo Molding Products, Inc., 230 Park Ave., New York 17, N.Y.
Corite Products, Inc., 6553 W George St., Chicago 34, Ill.
Cornell and Underhill, Inc., 1310 Jefferson St., Hoboken, N.J.

Corning Glass Works, (Ad p 253)
Corning, N.Y.

Corson Industries, 1228 Belmont Ave., Philadelphia 4, Pa.
Couch-Uthe Co., 140 S Olive St., Elyria, Ohio
Coyne & Paddock, Inc., 40-09 21st St., Long Island City 1, N.Y.
Craft Mfg. Co., 2301 Davis St., North Chicago, Ill.
Craftint Mfg. Co., 1615 Collamer Ave., Cleveland 10, Ohio
Crane Co., 836 S Michigan Ave., Chicago 5, Ill.
Crane Packing Co., 6400 Oakton St., Morton Grove, Ill.
Crawford & Doherty Foundry Co., 4604 SE 17th Ave., Portland, Ore.
Crescent Co., Inc., Carol Cable Co. Div., 90 Middle St., Pawtucket, R.I.
Crescent Plastics, Inc., 955 Diamond Ave., Evansville 7, Ind.
Crest Chemical Industries Corp., 72 Delavan St., Brooklyn 31, N.Y.
Crobalt, Inc., 2800 S State St., Ann Arbor, Mich.
Croname, Inc., 6275 Howard St., Chicago 48, Ill.
Cross Engineering Co., Carbondale, Pa.
Crown Metal Co., 121 E Washington St., Milwaukee 4, Wis.
Crown Non-Ferrous Foundry, Inc. Concord Ave., Chester, Pa.
Crucible Steel Co. of America, P.O. Box 2518, Pittsburgh 30, Pa.
Titanium and Vacuum Metal Products Div., P.O. Box 2518, Pittsburgh 30, Pa.
Trent Tube Co., P.O. Box 2518, Pittsburgh 30, Pa.
Crucible Steel Casting Co., Union Ave. & Penn R.R., Lansdowne, Pa.
Cruver Mfg. Co., 2460 W Jackson, Chicago 12, Ill.
CrystalX Corp., W Lenni Rd., Lenni Mills, Pa.
Cumberland Steel Co., 101 Williams St., Cumberland, Md.
Curtis Cos., Inc., American Plywood Div., New London, Wis.
Curtis Products Co., 7 Cherry Ave., Waterbury 4, Conn.
Curtis Screw Co., Inc., 19 Gull St., Buffalo 13, N.Y.

Curtiss-Wright Corp., Metals Processing Div., (Ad p 363)
706 Northland Ave., Buffalo 15, N.Y.

Cuyahoga Stamping Co., 10201 Harvard Ave., Cleveland 5, Ohio
Cyril Bath Co., 32342 Aurora Rd., Solon, Ohio

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Dacar Chemical Products Co., 1007 McCartney St., Pittsburgh, Pa.
Dahlin, C. A. Co., 2727 Clybourn Ave., Chicago 14, Ill.
Dalton Foundries, Inc., Lincoln & Jefferson Sts., Warsaw, Ind.

Damascus Tube Co., (Ad p 351)
P.O. Box 71, Greenville, Pa.

Dana Corp., Parish Pressed Steel Div., Box 1422, Reading, Pa.
Danby Mfg. Co., Portland, Mich.
Danielson Mfg. Co., 900 Holt St., Danielson, Conn.
Dapol Plastics, Inc., 53 Northboro St., Worcester 4, Mass.
Darby Corp., 1st & Walker Sts., Kansas City 15, Kan.
Dare Products, Inc., 860 Betterly Rd., Battle Creek, Mich.
Darling, L. A., Midwest Foundry Co. Div., 66-76 Clark St., Coldwater, Mich.
Darling Valve & Mfg. Co., Walnut & Marshall Sts., Williamsport, Pa.
Darlington Veneer Co., 4th St., Darlington, S.C.
Daubert Chemical Co., 333 N Michigan Ave., Chicago, Ill.
Davidson Rubber Co., 50 Brighton St., Charlestown 29, Mass.
Davis & Hemphill, 2000 Furnace Ave., Elkridge 27, Md.
Davis, Joseph Plastics Co., Kearny, N.J.
Davis Products Corp., 601 39th St., Brooklyn 32, N.Y.
Dawlen Corp., 1911 Fargo Rd., Jackson, Mich.
Day Co., 810 3rd Ave., NE, Minneapolis 13, Minn.
Day, James B. & Co., 1872 Clybourn Ave., Hollydale, Calif.
Dayton Bronze Bearing Co., 111 Front St., Dayton 2, Ohio
Dayton Foundry, 11803 Industrial Ave., Hollydale, Calif.
Dayton Malleable Iron Co., P.O. Box 980, Dayton 1, Ohio
G. H. R. Div., 400 Detrick St., Dayton 1, Ohio
Ironton Malleable Div., Ironton, Ohio
Meta-Mold Aluminum Co., 525 E Hamilton Rd., Cedarburg, Wis.
Ohio Malleable Div., Box 88, Sta. A, Columbus, Ohio
Pratt & Letchworth Div., 189 Tonawanda St., Buffalo 7, N.Y.
Dayton Rogers Mfg. Co., 2824 13th Ave., S, Minneapolis 7, Minn.
Dayton Rubber Co., Dayton 1, Ohio
Molded Products Div., P.O. Box 209, Three Rivers, Mich.

Dayton Steel Foundry Co., 1366 Miami Chapel Rd., Dayton 1, Ohio
Dearborn Stamping Co., 10501 Haggerty Ave., Dearborn, Mich.
Debevoise Co., 74 20th St., Brooklyn 32, N.Y.
Decatur Automatic Screw Machine Products Co., P.O. Box 26, Warrensburg, Ill.
Decatur Casting Co., 822 Dayton Ave., Decatur, Ind.
Decrow Engineering Corp., Main St., Middleport, N.Y.
Deerfield Mfg. Co., 4th Ave., Mason, Ohio
Defiance Metal Products Co., 21 Seneca St., Defiance, Ohio
Defiance Stamping Co., Perry & German Sts., Defiance, Ohio
De Laval Steam Turbine Co., 853 Nottingham Way, Trenton 2, N.J.
Delaware Tool Steel Corp., 34th & Market Sts., Wilmington, Del.
Delo Screw Products Co., 38 S Franklin St., Delaware, Ohio
Delta Plywood Corp., Cotton Plant, Ark.
Dennis Chemical Co., 2701 Papin St., St. Louis 3, Mo.
Denver Plastics, Inc., 15200 W Colfax Ave., Golden, Colo.
Dependable Automatic Screw Co., 282 S Lenard St., Waterbury 20, Conn.
Derby Castings Co., 593 N Main St., Seymour, Conn.
Deringer Metallurgical Corp., 8131 Monticello Ave., Skokie, Ill.
De Sanno Foundry & Machine Co., 1919 Peralta St., Oakland 7, Calif.
Designers Metal Corp., 469 E 159th St., Harvey, Ill.
De Soto Paint & Varnish Co., P.O. Box 186, Garland, Tex.
Detrex Chemical Industries, Inc., Box 501, R P K Annex 32, Detroit, Mich.
Detroit Brass & Malleable Co., 2968 7th St., Wyandotte, Mich.
Detroit Float & Stamping Co., 625 Monroe St., Detroit, Mich.
Detroit Gasket & Mfg. Co., Extruded Metals Div., 12640 Burt Rd., Detroit 23, Mich.
Detroit Stamping Co., 350 Midland St., Detroit 3, Mich.
Detroit Steel Corp., Portsmouth Div., Detroit 9, Mich.
Deuscher, H.P. Co., 7th & Hanover Sts., Hamilton, Ohio
Devcon Corp., Danvers, Mass.
Devoe & Raynolds Co., Inc., Jones-Dabney Co. Div., 1481 S 11th St., Louisville 8, Ky.
Dexter, C.H. & Sons, Inc., Windsor Locks, Conn.
Diamond Alkali Co., 300 Union Commerce Bldg., Cleveland 14, Ohio
Diamond Mfg. Co., W 8th St., Wyoming, Pa.
Die Cast Products, Inc., 621 W Rosecrans Ave., Gardena, Calif.
Diecast Corp., 522-524 Hupp Ave., Jackson, Mich.
Dietzel Lead Burning Co., Narrows Run Rd., Coraopolis, Pa.
Dimco-Gray Co., 207 E 6th St., Dayton 2, Ohio
Dip Seal Plastics, Inc., 2311 23rd Ave., Rockford, Ill.
Dirilyte Co. of America, Inc., 1142 S Main St., Kokomo, Ind.
Disogrin Industries, Inc., 510 S Fulton Ave., Mount Vernon, N.Y.
Diversey Corp., Metal Industries Div., 1820 Roscoe St., Chicago 13, Ill.
Division Lead Co., 7742 W 61st Pl., Summit, Ill.
Dixie Aluminum Corp., 304 E 2nd Ave., Rome, Ga.
Dixie Bronze Co., P.O. Box 1148, Birmingham 1, Ala.
Dixie Galvanizing & Tank Co., 1901 McQuade St., Jacksonville, Fla.
Dixie Lead Co., Sargent Rd., Box 8625, Dallas 16, Tex.
Dixie Plastics Mfg. Co., 3017 N Galves St., New Orleans, La.
Dixon Corp., Burnside St., Bristol, R.I.
Dixon, Joseph Crucible Co., Wayne & Monmouth Sts., Jersey City 3, N.J.
Dixon Sintaloy, Inc., 535 Hope St., Stamford, Conn.
Dodge Fibers Corp., John St., Hoosick Falls, N.Y.
Dodge Mfg. Corp., 500 S Union St., Mishawaka, Ind.
Dolin Metal Products, Inc., 315 Lexington Ave., Brooklyn 16, N.Y.
Dollin Corp., (Ad p 350)
650 S 21st St., Irvington 11, N.J.
Donegal Steel Foundry Co., 601 E Market St., Marietta, Pa.
Donovan, F. C. Inc., 192 South St., Boston, Mass.
Dormont Mfg. Co., 5607 Butler St., Pittsburgh 1, Pa.
Dostal Foundry & Machine Co., Box 180, Pontiac, Mich.
Douglas & Sturgess, 475 Bryant St., San Francisco 7, Calif.
Dow Chemical Co., Midland, Mich.
Dobeckmun Co. Div., 3301 Monroe Ave., Cleveland 13, Ohio
Magnesium Div., Midland, Mich.
Plastics Div., (Ad pp 189, 198)
Midland, Mich.
Dow Corning Corp., P.O. Box 592, Midland, Mich.
Downer, Hunnewell, Inc., Mono-Seal Products Div., 44 Garden St., Everett 49, Mass.
Downington Iron Works, 161 Wallace St., Downington, Pa.
Dravo Corp., 102 5th Ave., Pittsburgh 22, Pa.
Drawn Metal Tube Co., 101 Elm St., Thomaston, Conn.
Dresser Industries, Inc., Dresser Mfg. Div., 43 Fisher Ave., Bradford, Pa.
Dresser Operations, Inc., Clark Bros. Co. Div., Lincoln Ave. & 5th St., Olean, N.Y.
Drexel Screw Products Co., 6200 S Oakley Ave., Chicago 36, Ill.
Driver, Wilbur B. Co., (Ad p 131)
1875 McCarter Hwy., Newark 4, N.J.
Driver-Harris Co., 201 Middlesex St., Harrison, N.J.
Driv-Lok Sales Corp, 777 Park Ave., Sycamore, Ill.
Duane Specialties, Ltd., 210 Parkhurst St., Newark 5, N.J.
Du-Co Ceramics Co., Box 278, Saxonburg, Pa.
Duffin Mfg. Co., 2307 Leavitt Rd., Lorain, Ohio
Duluth Brass Works Co., 5002 Ramsey St., Duluth 7, Minn.
Dumont Corp., 607 Irwin St., San Rafael, Calif.
Dunnican Assoc., 352 Plymouth Rd., Union, N.J.
Duplex Mfg. Corp., 104 Depot St., Sherman, N.Y.
Duplican Co., Inc., 1221 Turnpike Rd., Westboro, Mass.
du Pont de Nemours, E. I. & Co., Inc., Wilmington 98, Del.
Elastomer Chemicals Div., Wilmington 98, Del.
Fabrics Div., Wilmington 98, Del.
Film Div., Wilmington 98, Del.
Finishes Div., Wilmington 98, Del.
Pigments Div., Wilmington 98, Del.
Polychemicals Dept., (Ad pp 195, 214-15)
Wilmington 98, Del.
Textile Fibers Div., Wilmington 98, Del.
Dura Flex Co., 2043 Colorado Ave., Santa Monica, Calif.
Dura Plastics of New York, Inc., 303 5th Ave., New York 16, N.Y.
Duralac Chemical Corp., 84 Lister Ave., Newark 5, N.J.
Dura-Lee Corp., 908 Broadway, Kansas City, Mo.
Duraloy Co., (Ad p 359)
Bridge St., Scottdale, Pa.
Durethene Corp., 1859 S 55th Ave., Chicago 50, Ill.
Duriron Co., Inc., 450 N Findlay St., Dayton, Ohio
Duro Screw & Mfg. Co., 1064 Springfield Rd., Union, N.J.
Du-Wel Metal Products, Inc., P.O. Box 307, Bangor, Mich.

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Eagle-Picher Co., American Bldg., Cincinnati 1, Ohio
Chicago Vitreous Corp. Div., 1425 S 55th Ct., Cicero 50, Ill.
Fabricon Products Div., 1721 W Pleasant Ave., River Rouge 18, Mich.
Earl Paint Corp., 240 Genesee St., Utica 2, N.Y.
Earley, Sam C. Corp., 3230 Monroe St., Toledo 6, Ohio
East Birmingham Bronze Foundry Co., 831 N 36th Way, Birmingham 4, Ala.
Eastern Brass & Copper Co., 1122 E 180th St., New York 60, N.Y.
Eastern Machine Screw Corp., Truman & Barclay Sts., New Haven 6, Conn.
Eastern Malleable Iron Co., P.O. Box 349, Wilmington 99, Del.
Eastern Rolling Mills, Inc., 1122 E 180th St., New York 60, N.Y.
Eastern Smelting & Refining Corp., 109 W Brookline St., Boston 18, Mass.
Eastern Stainless Steel Corp., P.O. Box 1975, Baltimore 3, Md.
Eastern Tool & Mfg. Co., 1 Montgomery St., Belleville 9, N.J.
Eastman Kodak Co., 343 State St., Rochester 4, N.Y.
Cellulose Products Sales Div., 343 State St., Rochester 4, N.Y.
Eastman Chemical Products, Inc., Kingsport, Tenn.
Easton Plastic Products Co., Inc., 900 Line St., Easton, Pa.
Eaton Mfg. Co., 9711 French Rd., Detroit, Mich.
Foundry Div., 700 E Huron, Vassar, Mich.
Powdered Metals Div., 325 Jay St., Goldwater, Mich.
Reliance Div., 25 Charles Ave., Massillon, Ohio
Eberhard Faber Pencil Co., 37 Greenpoint Ave., Brooklyn, N.Y.
Eberhart Steel Products, Powdered Metals Div., 317 E Jefferson Blvd., Mishawaka, Ind.
Eby, Hugh H. Co., 4701 Germantown Ave., Philadelphia 20, Pa.
Eclipse Plastic Industries, Inc., Box 430, Sarasota, Fla.
Economy Machine Products Co., 5214 W Lawrence Ave., Chicago 30, Ill.
Edgar Plastic Kaolin Co., Materdyne Ave., Edgar, Fla.
Edgcomb Steel & Aluminum Corp., (Ad p 70)
Hillside Ave., Hillside, N.J.
Edna Lite Optical Co., Inc., 200 N Water St., Peekskill, N.Y.
Egan & Hausman Co., Inc., 9-02 43rd Rd., Long Island City 1, N.Y.
Egyptian Lacquer Mfg. Co., P.O. Box 444, Newark 1, N.J.
Ehrsam, J. B. & Sons Mfg. Co., Enterprise, Kan.
Eimco Corp., American Foundry & Machine Div., P.O. Box 300, Salt Lake City 10, Utah
Ekstrand & Tholand, 420 Lexington Ave., New York 17, N.Y.
Elastic Stop Nut Corp. of America, 2330 Vauxhall Rd., Union, N.J.
Elastomer Chemical Corp., 212 Wright St., Newark 7, N.J.
Elchinger, Charles F., 916 Magazine St., New Orleans 12, La.
Elco Tool and Screw Corp., 1800 Broadway, Rockford, Ill.
Electric Auto-Lite Co., Champlain & Mulberry Sts., Toledo 1, Ohio
Woodstock Div., 501 Clay St., Woodstock, Ill.
Electric Materials Co., Clay & Washington Sts., North East, Pa.
Electric Steel Castings Co., 1045 Main St. Speedway, Indianapolis 24, Ind.
Electric Steel Foundry Co., 2141 NW 25th Ave., Portland 10, Ore.
Electric Storage Battery Co., Stokes Molded Products Div., Taylor St. & Webster, Trenton 4, N.J.
Electrical Refractories Co., East Palestine, Ohio
Electro Chemical Engineering & Mfg. Co., 750 Broad St., Emmaus, Pa.
Electro Refractories & Abrasives Corp., Willett Rd., Lackawanna 18, N.Y.
Electrocast Steel Foundry Co., 4701 W 15th Place, Cicero 50, Ill.
Electrofilm, Inc., 7116 Laurel Canyon Blvd., North Hollywood, Calif.
Electron Corp., 651 Rio Grande Ave., Littleton, Colo.
Electronic Parts Mfg. Co., 508 25th St., Union City, N.J.
Elgin National Watch Co., 107 National St., Elgin, Ill.
Eljay Corp., 2900 Herbert St., Baltimore 16, Md.
Elk Engineering Works, Inc., 220 Stackpole St., St. Marys, Pa.
Elkhart Foundry & Machine Co., Inc., 220-330 S Elkhart Ave., Elkhart, Ind.
Elkhart Iron Works, 1217-33 Broad St., St. Joseph, Mich.
Elliott Bros. Steel Co., 902-914 N Cedar St., New Castle, Pa.
Ellwood City Iron & Wire Co., 416 Pittsburgh Circle, Ellwood City, Pa.
Elm Coated Fabrics Co., Inc., 261 5th Ave., New York 16, N.Y.
Elsby, J.S. Inc., 3223 W Burnham St., Milwaukee 15, Wis.
Emerson & Cuming, Inc., 869 Washington St., Canton, Mass.
Emerson-Sack-Warner Corp., 85 Washington St., Somerville, Mass.
Emery, George D. Co., 220 11th Ave., New York, N.Y.
Emmaus Foundry & Machine Co., 4th & Furnace Sts., Emmaus, Pa.
Empire Foundry Co., Inc., 429 3rd St., Oakland 7, Calif.
Empire Metal Co., 820 E Water St., Syracuse 3, N.Y.
Empire Pattern and Foundry Co., P.O. Box 1647, Tulsa 1, Okla.
Empire Spring Co., 210 S Albe St., Elyria, Ohio
Empire Steel Castings, Inc., Frush Valley Rd., Laureldale, Pa.
Enamel Products Co., 341 Eddy Rd., Cleveland 8, Ohio
Endicott Forging & Mfg. Co., Inc., 1901 North St., Endicott, N.Y.
Enflo Corp., Fellowship Rd. & Rt. #73, Maple Shade, N.J.
Engelhard Industries, Inc., 904 Passaic Ave., East Newark, N.J.
American Platinum & Silver Div., (Ad p 395)
231 New Jersey R.R. Ave., Newark 5, N.J.
Amersil Quartz Div., 685 Ramsey Ave., Hillside, N.J.
Makepeace, D.E. Div., Pine & Durham Sts., Attleboro, Mass.
Engineered Nylon Products, Inc., 1318 S Olive St., South Bend, Ind.
Engineered Plastics, Inc., American Sinterings Div., P.O. Drawer P, Watertown, Conn.

Addresses of Suppliers

Engineered Precision Casting Co., Highway 79, P.O. Box 68, Matawan, N.J.
Engineering Products & Specialties, Inc., Dunnel Lane, Pawtucket, R.I.
Englander Co., Inc., Industrial Products Div., 227 N. Warwick Ave., Baltimore 23, Md.
Enjay Co., Inc., (Ad p 181)
15 W 51st St., New York 18, N.Y.
Enoch Mfg. Co., P.O. Box 5201, Portland 16, Ore.
Enterprise Galvanizing Co., 2507 E Cumberland St., Philadelphia 25, Pa.
Enterprise Wheel & Car Corp., P.O. Box 151, Bristol, Va.
Enthone, Inc., 442 Elm St., New Haven 8, Conn.
Erie Bolt & Nut Co., 1325 Liberty St., Erie, Pa.
Erie Bronze Co., 19th & Chestnut Sts., Erie, Pa.
Erie Casting Co., 1534 German St., Erie, Pa.
Erie Ceramic Arts Co., (Ad p 282)
3120 W 22nd St., Erie, Pa.
Erie Enameling Co., 1400 W 20th St., Erie 4, Pa.
Erie Malleable Iron Co., 680 W 12th St., Erie, Pa
Erie Resistor Corp., Plastics Div., 644 W 12th St., Erie, Pa.
Erie Scientific Corp., 693 Seneca St., Buffalo 10, N.Y.
Erskine Precision Wire Corp., 210 S Broad St., Emporium, Pa.
Ervite Corp., 4000 W Ridge Rd., Erie, Pa.
Escambia Chemical Corp., 261 Madison Ave., New York 16, N.Y.
Essential Bar Products Co., 2526 Brooklyn Road, Jackson, Mich.
Essex Wire Corp., 1601 Wall St., Fort Wayne, Ind.
Carolina Industrial Plastics Div., Mount Airy, N.C.
Magnet Wire Div., 1601 Wall St., Fort Wayne, Ind.
Est Co., Inc., Grafton, Wis.
Etched Products Corp., 39-01 Queens Blvd., Long Island City 1, N.Y.
Eureka Electric Products Co., Clay St., North East, Pa.
Eutectic Welding Alloys Corp., 40-40 172nd St., Flushing 58, N.Y.
Evans, George Corp., 121 37th St., Moline, Ill.
Evans Metal Co., 740 Lambert Dr. NE, Atlanta 5, Ga.
Evans Products Co., Hardboard Div., P.O. Box 651, Corvallis, Ore.
Everard Tap & Die Corp., 215 E 144th St., New York 51, N.Y.
Everlite Corp., 1213 E Cherry St., Seattle 22, Wash.
Exalco Mfg. Co., (Ad p 344)
46 Sheldon Rd., Berea, Ohio
Excelsior Leather Washer Mfg. Co., Inc., 720 Chestnut St., Rockford, Ill.
Exeter Mfg. Co., 1451 Broadway, New York 36, N.Y.
Extruders, Inc., 3232 W El Segundo Blvd., Hawthorne, Calif.

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Fabristeel Products, Inc., 21500 W 8 Mile Rd., Detroit 41, Mich.
Fahralloy Co., 149th St. & Loomis St., Harvey, Ill.
Fairbanks, Morse & Co., Beloit, Wis.
Fairchild Engine & Airplane Corp., Al-Fin Div., Comac Rd., Deer Park, N.Y.
Fairchild Screw Products, Inc., White St., Winsted, Conn.
Fairfield Aluminum Castings Co., 603 N 8th St., Fairfield, Iowa
Fairmont Aluminum Co., Fairmont, W. Va.
Falge Engineering Corp., 4733 Elm St., Bethesda 14, Md.
Falk Corp., 3001 W Canal St., Milwaukee 1, Wis.
Falls Machine Co., 1625 Massillon Rd., Akron 12, Ohio
Falstrom Co., 86 Falstrom Ct., Passaic, N.J.
Fanner Mfg. Co., Brookside Park, Cleveland 9, Ohio
Munray Products Div., 12400 Crossburn Ave., Cleveland 11, Ohio
Fansteel Metallurgical Corp., (Ad pp 138-39)
2200 Sheridan Rd., North Chicago, Ill.
Farley & Loetscher Mfg. Co., Plastics Div., 7th & White, Dubuque, Iowa
Farnam Mfg. Co., 2000 Sweeten Creek Rd., Asheville, N.C.
Farrel-Birmingham Co., Inc., 25 Main St., Ansonia, Conn.
Farrelloy Co., 1243-45 N 26th St., Philadelphia 21, Pa.
Farwell Metal Fabricating, 77 W Fairfield Ave., St. Paul 7, Minn.
Fasson Products, 250 Chester St., Painesville, Ohio
Faultless Rubber Co., Ashland, Ohio
Fearon Foundry Co., 1420 W Kinzie St., Chicago 22, Ill.
Federal Adhesives Corp., 210 Wythe Ave., Brooklyn 11, N.Y.
Federal Die Casting Co., 2226 N Elston, Chicago, Ill.
Federal Machine and Welder Co., 1745 Overland Ave. NE, Warren, Ohio
Federal Malleable Co., 805 S 72nd St., Milwaukee, Wis.
Federal Screw Works, Congdon St., Chelsea, Mich.
Federal Steel Products Corp., 415 N St. Charles St., Houston 3, Tex.
Federal Tool Corp., 3600 W Pratt Blvd., Chicago 45, Ill.
Federal Tool Mfg. Co., 3600 Alabama Ave., Minneapolis 16, Minn.
Felters Co., (Ad pp 247, 254)
220 South St., Boston 11, Mass.
Femco Mfg. Co., Inc., 22845 Hoover Rd., Detroit 5, Mich.
Fenestra, Inc., 2250 E Grand Blvd., Detroit 11, Mich.
Ferro Corp., 4150 E 56th St., Cleveland 5, Ohio
Fiber Glass Div., Fiber Glass Rd., Nashville 11, Tenn.
Louthan Mfg. Co., P.O. Box 781, East Liverpool, Ohio
Ferro Enameling Co., 1100 57th Ave., Oakland 21, Calif.
Ferro Powdered Metals, Box 312, Salem, Ind.
Ferro-Co Corp., Schori Process Div., 8-11 43rd Rd., Long Island City 1, N.Y.
Fetcher, M. B. Co., 3558 Garfield St., Detroit 7, Mich.
Fiber Glass Industries, Inc., Amsterdam, N.Y.
Fibercast Corp., 100 S Lincoln, Sand Springs, Okla.
Fiberfil, Inc., Fox Farm Road, Warsaw, Ind.
Fiberite Corp., 516 W 4th, Winona, Minn.
Fibron Products, Inc., 500 Fibron Bldg., 45 Mechanic St., Buffalo 2, N.Y.
Fidelity Chemical Products Corp., 470 Frelinghuysen Ave., Newark 12, N.J.
Fidelity Felt & Mfg. Co., 22 W 15th St., New York 11, N.Y.
Figley Die & Stamping Co., 401 Agnes St., Defiance, Ohio
Filon Plastics Corp., 2051 E Maple Ave., El Segundo, Calif.
Filpaco Industries, Inc., 2426 S Michigan Ave., Chicago 16, Ill.
Fine Organics, Inc., 209-211 E 19th St., New York, N.Y.
Firestone Plastics Co., Firestone Blvd., Pottstown, Pa.
Firestone Tire & Rubber Co., 1200 Firestone Pkwy., Akron 17, Ohio
Firth Sterling, Inc., 3113 Forbes St., Pittsburgh, Pa.
Fischer Casting Co., Inc., P.O. Box M, Dunellen, N.J.
Fischer Special Mfg. Co., 450 Morgan St., Cincinnati 20, Ohio
Fish-Schurman Corp., 70 Portman Rd., New Rochelle, N.Y.
Fitchburg Foundry, Inc., Benson St., Fitchburg, Mass.
Fitzgibbons Boiler Co., Inc., Oswego, N.Y.
FitzSimons Mfg. Co., 3775 E Outer Drive, Detroit 34, Mich.
Fletcher Enamel Co., P.O. Box 67, Dunbar, W. Va.
Flexfirm Products, 2300 N Chico Ave., El Monte, Calif.
Flexible Tubing Corp., Guilford, Conn.
Flexonics Corp., 1315 S 3rd Ave., Maywood, Ill.
Flexrock Co., 3609 Filbert St., Philadelphia, Pa.
Flood City Brass & Electric Co., Messenger & Elder Sts., Johnstown, Pa.
Florence Pipe Foundry & Machine Co., Front St., Florence, N.J.
Florin Foundry & Mfg. Co., Florin, Pa.
Flynn & Emrich Co., 301 Holliday St., Baltimore 2, Md.
Flynn, Michael Mfg. Co., 700 E Godfrey Ave., Philadelphia 24, Pa.
Foamade Industries, 14851 W 11 Mile Rd., Oak Park 37, Mich.
Foamalum Corp., (Ad p 133)
508 Water St., Peru, Ill.
Follansbee Steel Corp., Sheet Metal Specialty Div., P.O. Box 567, Follansbee, W. Va.
Food Machinery & Chemical Corp., F M C Organic Chemicals Div., 161 E 42nd St., New York 17, N.Y.
Foote Mineral Co., 18 W Chelten Ave., Philadelphia 44, Pa.
Fordsell Machine Products Co., 4433 E 8 Mile Rd., Van Dyke, Mich.
Forg, Peter Mfg. Co., Park St., Somerville 43, Mass.
Formed Tubes, Inc., Prairie & Albert Sts., Sturgis, Mich.
Fort Howard Steel & Wire Co., 200 9th St., Green Bay, Wis.
Fort Worth Steel & Machinery Co., 3504 Jackson St., Fort Worth, Tex.
Foss Mfg. Co., Plastics Div., 225 2nd Ave., Twin Falls, Id.
Foster Aluminum Alloy Products Corp., Pearl St., Forestville, N.Y.
Foster Grant Co., 289 N Main St., Leominster, Mass.
Foster Wheeler Corp., 165 Broadway, New York, N.Y.
Fox Co., 3400 Beekman St., Cincinnati, Ohio
Fox Edge Co., Inc., 1995 Middlesex St., Lowell, Mass.
Fox Products Co., 4720 N 18th St., Philadelphia 41, Pa.
France, J. H. Refractories Co., Snow Shoe, Pa.
Franklin Cotton Mill Co., 1108 Central Pkwy., Cincinnati 10, Ohio
Franklin Glue Co., 119 Chestnut St., Columbus 15, Ohio
Franklin Mineral Products Co., P.O. Box 28, Franklin, N.C.
Franklin Plastics, Inc., 315 Grant St., Franklin, Pa.
Frasse, Peter A. & Co., Inc., (Ad p 365)
17 Grand St., New York 13, N.Y.
Frederick Iron & Steel, Inc., 7th & East Sts., Frederick, Md.
Fremont Casting Co., 105 Fremont St., Worcester, Mass.
Frenchtown Porcelain Co., Frenchtown, N.J.
Friedrich & Dimmock, Inc., Lincoln Ave., Millville, N.J.
Frisby, R. J. Mfg. Co., 246 N Western Ave., Chicago 12, Ill.
Fromson Orban Co., Inc., 261 Madison Ave., New York, N.Y.
Frontier Bronze Corp., 4870 Packard Road, Niagara Falls, N.Y.
Frost Paint & Oil Corp., 1203 NE Tyler, Minneapolis, Minn.
Frost Rubber Co., 1407 N Dayton St., Chicago 22, Ill.
Fry Plastics Co., 7826 S Vermont Ave., Los Angeles 44, Calif.
Fryling Mfg. Co., 531 W 11th St., Erie, Pa.
Fuller, H. B. Co., 255 Eagle, St. Paul 2, Minn.
Fuller, W. P. & Co., 301 Mission St., San Francisco, Calif.
Fullerton Mfg. Co., 343 E Santa Fe Ave., Fullerton, Calif.
Fulton Foundry & Machine Co., Inc., Cleveland, Ohio
Fulton Gold Refiners Corp., 71 Fulton St., New York 38, N.Y.
Funkhouser Co., P.O. Box 569, Hagerstown, Md.
Furane Plastics, Inc., 4516 Brazil St., Los Angeles 39, Calif.

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G. & C. Foundry Co., Monroe & Olds St., Sandusky, Ohio
G & G Mfg. Co., 3223 W Fillmore St., Chicago 24, Ill.
G & Z Automatic Products Co., 2434 Brooklyn Rd., Jackson, Mich.
Gale Mfg. Co., 115 N Albion St., Albion, Mich.
Galigher Co., 545 W 8th St., P.O. Box 209, Salt Lake City 10, Utah
Gamble Bros., Inc., Special Products Div., 4601 Allmond Ave., Louisville 9, Ky.
Gantner Screw Products Co., Inc., 20 S Walnut St., Springfield, Ohio
Gar Precision Parts, Inc., 190 Henry St., Stamford, Conn.
Garco Mfg. Co., Inc., 744 N Ada St., Chicago 22, Ill.
Garden State Forge Co., 1501 Jersey St., South Plainfield, N.J.
Gardner-Denver Co., 100 Williamson St., Quincy, Ill.
Garfield Mfg. Co., 10 Midland Ave., Wallington, N.J.
Garlock Packing Co., (Ad p 361)
402 Main St., Palmyra, N.Y.
U.S. Gasket Plastics Div., 600 N 10th St., Camden 1, N.J.
Gartland Foundry Co., 4th & Grant Sts., Terre Haute, Ind.
Gartland-Haswell Foundry, Inc., 430 W Park St., Sidney, Ohio
Gary Lynn Co., 926 York St., Cincinnati 14, Ohio
Gary Steel Products Corp., P.O. Box 449, Lynchburg, Va.
Gates Engineering Co., 100 S West St., Wilmington 99, Del.
Gates Rubber Co., 999 S Broadway, Denver, Colo.
Gatke Corp., Engineering Div., 228 N LaSalle St., Chicago 1, Ill.
Geauga Industries Co., Middlefield, Ohio

In contacting suppliers, please mention the Materials Selector

General Alloys Co., 465 W 1st St., South Boston, Mass.
General Aluminum Mfg. Co., 3027 E 55th St., Cleveland 27, Ohio
General American Transportation Corp., 135 S LaSalle St., Chicago 90, Ill.
Parker-Kalon Div., 1 Peekay Dr., Clifton, N.J.
Plate & Welding Div., 135 S LaSalle St., Chicago 90, Ill.
General Aniline & Film Corp., Antara Chemicals Div., 435 Hudson St., New York 14, N.Y.
General Asbestos Gasket Mfg. Corp., 1029 Lafayette Ave., St. Louis 4, Mo.
General Cable Corp., 420 Lexington Ave., New York 17, N.Y.
General Ceramics Corp., Crows Mill Rd., Keasbey, N.J.
General Dynamics Corp., Liquid Carbonic Div., 3100 S Kedzie Ave., Chicago 23, Ill.
General Electric Co., 1 River Rd., Schenectady 5, N.Y.
Chemical Materials Dept., 1 Plastics Ave., Pittsfield, Mass.
Chemical & Metallurgical Div., 2200 N 22nd St., Decatur, Ill.
Foundry Dept., 1 River Rd., (Bldg. 96), Schenectady, N.Y.
Insulating Materials Dept., 69 River Rd., Schenectady 5, N.Y.
Laminated Products Dept., Coshocton, Ohio
Lamp Wire & Phosphors Dept., 21800 Tungsten Rd., Cleveland 17, Ohio
Metallurgical Products Dept., P.O. Box 237, Roosevelt Park Annex, Detroit 32, Mich.
Silicone Products Dept., (Ad p 251)
Waterford, N.Y.
General Engineering Works, 4701 W Division St., Chicago 51, Ill.
General Extrusions, Inc., (Ad p 342)
4040 Lake Park Rd., Youngstown 12, Ohio
General Findings & Supply Co., Industrial Div., School & Pearl Sts., Attleboro, Mass.
General Foundry & Mfg. Co., Flint, Mich.
General Gasket, Inc., Middletown, Conn.
General Industries Co., Molded Plastic Div., Taylor & Olive Sts., Elyria, Ohio
General Iron Works Co., P.O. Box 2490, Denver 1, Colo.
General Malleable Corp., 706 E Main St., Waukesha, Wis.
General Metals Corp., 550 85th Ave., Oakland, Calif.
General Metals Powder Co., 130 Elinor Ave., Akron 5, Ohio
General Mills, Inc., Chemical Div., S Kensington Rd., Kankakee, Ill.
General Motors Corp., General Motors Bldg., Detroit, Mich.
Central Foundry Div., 37 Florence St., Saginaw, Mich.
Fabricast Div., 3rd & Monon, Bedford, Ind.
Moraine Products Div., 1420 Wisconsin Blvd, Dayton 1, Ohio
Rochester Products Div., 1000 Lexington Ave., Rochester 3, N.Y.
General Plastics Corp., 1400 N Washington St., Marion, Ohio
General Plastics Corp., 165 3rd Ave., Paterson, N.J.
General Plastics Mfg. Co., 3481 S 35th St., Tacoma 9, Wash.
General Powdered Metal Products, Inc., Holly Corp., 523 West Ave., Norwalk, Conn.
General Refractories Co., 1520 Locust St., Philadelphia 2, Pa.
General Screw Products Corp., 1190 Brooks Ave., Rochester 19, N.Y.
General Sintering Corp., 1830 N 32 Ave., Melrose Park, Ill.
General Smelting Co., 2901 E Westmoreland St., Philadelphia, Pa.
General Tire & Rubber Co., 1700 Factory Ave., Marion, Ind.
Chemical Div., 1485 Archwood, Akron 9, Ohio
Respro Div., 530 Wellington Ave., Cranston 10, R.I.
Textileather Div., 607 Madison Ave., Toledo 8, Ohio
General Veneer Mfg. Co., 8653 Otis, South Gate, Calif.
Genesee Laboratory, Inc., 16 Garden St., Auburn, N.Y.
Geometric Stamping Co., 1111 E 200th St., Cleveland 17, Ohio
George, P. D. Co., 5100 N 2nd St., St. Louis, Mo.
Georgia Iron Works, Augusta, Ga.
Georgia-Pacific Corp., Equitable Bldg., Portland, Ore.
Gering Products, Inc., N 7th St. & Monroe Ave., Kenilworth, N.J.
Gerstenslager Co., E Bowman St., Wooster, Ohio
Geuder, Paeschke & Frey Co., 324 N 15th St., Milwaukee 1, Wis.
Giant Grip Mfg. Co., 113 Osceola St., Oshkosh, Wis.
Gibb Walton Leather Co., 54th & Grays Ferry Ave., Philadelphia 43, Pa.
Gibson Electric Co., Box 545, Belmont, Pa.
Gibson & Kirk Co., Warner & Bayard St., Baltimore 30, Md.
Gilbert & Bennett Mfg. Co., Georgetown, Conn.
Gilbert Brass Foundry Co., 5036 Farlin Ave., St. Louis 15, Mo.
Gillett & Eaton, Inc., 847 Doughty, Lake City, Minn.
Gladding, McBean & Co., 2901 Los Feliz Blvd., Los Angeles 39, Calif.
Glamorgan Pipe and Foundry Co., P.O. Drawer 740, Lynchburg, Va.
Glasby, J. P. Mfg. Co., Inc., 1 Montgomery St., Belleville 9, N.J.
Glaskyd, Inc., Eckel Rd., Perrysburg, Ohio
Glass Laboratories, 863 65th St., Brooklyn 20, N.Y.
Glass Reinforced Plastics Corp., 405 W Sophia, Maumee, Ohio
Glastic Corp., 4321 Glenridge Rd., Cleveland 21, Ohio
Glenn, Joseph & Sons, Inc., Clifton Hts., Pa.
Glidden Co., 1717 Summer St., Hammond, Ind.
Chemicals-Pigments-Metals Div. (Ad p 347)
3901-3915 Hawkins Pt. Rd., Baltimore 26, Md.
Globe Imperial Corp., Plastic-Seal Div., 2038 Kishwaukee, Rockford, Ill.
Globe Industries, Inc., Supermet Div. (Ad p 354)
1460 Cincinnati St., Dayton 8, Ohio
Globe Paint Works, Inc., P.O. Box 36, Williamsport, Pa.
Globe Steel Abrasive Co., 238 1st Ave., Mansfield, Ohio
Globe Union, Inc., Centralab Div. (Ad p 246)
946 E Keefe Ave., Milwaukee 1, Wis.
Glo-Brite Products, Inc., 6415 N California Ave., Chicago 45, Ill.
Glover Machine Works, Butler St., Marietta, Ga.
Gluntz Brass & Aluminum Foundry Co., 10815 Harvard Ave., Cleveland 5, Ohio
Gold Leaf & Metallic Powders, Inc., 145 Nassau St., New York, N.Y.
Goldsmith Bros. Smelting & Refining Co., 111 N Wabash Ave., Chicago 2, Ill.
Gomar Mfg. Co., Inc., 1501 W Blancke St., Linden, N.J.
Goodrich, B.F. Chemical Co., 3135 Euclid Ave., Cleveland 15, Ohio
Hood Rubber Co. Div., 99 Nichols Ave., Watertown, Mass.
Sponge Products Div., Shelton, Conn.
Goodrich, B.F. Industrial Products Co., Marietta, Ohio
Goodrich-Gulf Chemicals, Inc., 3121 Euclid Ave., Cleveland 15, Ohio
Goodyear Tire & Rubber Co., 1144 E Market St., Akron 16, Ohio
Gordon Chemicals, Inc., 500 A St., Wilmington 99, Del.
Goshen Rubber Co., Inc. (Ad p 332)
1525 S 19th St., Goshen, Ind.
Goslin Birmingham Mfg. Co., Inc., 3521 10th Ave. N, Birmingham 1, Ala.
Gotham Plastics Corp., 220 E 134 St., New York 51, N.Y.
Gowanda Furnaces, Inc., 7 Palmer St., Gowanda, N.Y.
Grace, W.R. & Co., 7 Hanover Sq., New York, N.Y.
Dewey & Almy Chemical Co. Div., 62 Wittemore Ave., Cambridge 40, Mass.
Polymer Chemicals Div., 225 Allwood Rd., Clifton, N.J.
Grafton Foundry Co., 1003 Bridge St., Grafton, Wis.
Graham, James Co., 293 Wooster St., New Haven Conn.
Gra-Iron Foundry Corp., 501 S 12th Ave., Marshalltown, Iowa
Grammes, L.F. & Sons, Inc., 380 Union St., Allentown, Pa.
Grand Haven Stamped Products Co., Griffen & Madison Sts., Grand Haven, Mich.
Grand Rapids Brass Co., 420 50th St., SW, Grand Rapids 8, Mich.
Grand Rapids Varnish Corp., 1350 Steele St., SW, Grand Rapids, Mich.
Grand Sheet Metal Products Co., Consumer Products Div., 2055 Ruby St., Melrose Park, Ill.
Granite City Steel Co., 20th & Madison Aves., Granite City, Ill.
Graphite Metallizing Corp., 1058 Nepperhan Ave., Yonkers 3, N.Y.
Graphite Specialties Corp., (Ad p 252)
64th St. & Pine Ave., Niagara Falls, N.Y.
Grass, M.J. Machine Products Co., 19 Northampton St., Buffalo 9, N.Y.
Graton & Knight Co., Inc., 356 Franklin St., Worcester, Mass.
Graver Tank & Mfg. Co., Inc., 4809 Tod Ave., East Chicago, Ind.
Gray-Syracuse, Inc., W Seneca St., Manlius, N.Y.
Great American Industries, Inc., Rubatex Div., Bedford, Va.
Grede Foundries, Inc., 1320 S 1st St., Milwaukee 1, Wis.
Green Bay Foundry & Machine Works, 401 S Broadway, Green Bay, Wis.
Green, A.P. Fire Brick Co., Mexico, Mo.
Greenback Industries, Inc., 2527 W Maple Rd., Birmingham, Mich.
Greene, G.G. Corp., Warren, Pa.
Greene Mfg. Co., 1028 Douglas Ave., Racine, Wis.
Greenlee Foundry Co., 4600 W 14th St., Chicago 50, Ill.
Green-Walker Galvanizing Co., Inc., 5002 Jefferson Highway, New Orleans 21, La.
Greer Stop Nut Co., 2620 W Flournoy St., Chicago 12, Ill.
Gregg Metal Products Co., 1333 N 9th St., Milwaukee 5, Wis.
Gregory Industries Inc., Nelson Stud Welding Div., 28th St. & Toledo Ave., Lorain, Ohio
Gregory Thomas Galvan Works, 4900 Grand Ave., Maspeth 78, N.Y.
Grems Mfg. Co., 5635 S 6th St., Klamath Falls, Ore.
Grey, C.M. Industries, Inc., 358 Central Ave., East Orange, N.J.
Gries Reproducer Corp., (Ad pp 338, 402)
153 Beechwood Ave., New Rochelle, N.Y.
Grimes Mfg. Co., Plastic Research Products, 200 Beech St., Urbana, Ohio
Grimm Foundry Co., Inc., Chimney Rock Rd., Bound Brook, N.J.
Grip Nut Co., Broad & Maple Sts., South Whitley, Ind.
Groov-Pin Corp., 1125 Hendricks Causeway, Ridgefield, N.J.
Gross, Willard N., Inc., 224 Highland Ave., Westmont, Collingswood, N.J.
Guarantee Specialty Mfg. Co., 9651 Carr Ave., Cleveland 8, Ohio
Guilfoy Cornice Works, 1234 Howard St., San Francisco 3, Calif.
Gulton Industries, Inc., 212 Durham Ave., Metuchen, N.J.
Gunite Foundries Corp., 302 Peoples Ave., Rockford, Ill.
Gustin-Bacon Mfg. Co., 210 W 10th St., Kansas City 5, Mo.

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H & H Foundry Machine Co., P.O. Box 238, Jeanette, Pa.
H & H Screw Products, Inc., 570 Elk St., Buffalo 10, N.Y.
H. & H. Screw Products Mfg. Co., 1883 Mineral Spring Ave., North Providence 11, R.I.
H & H Tube & Mfg. Co., 263 N Forman, Detroit 17, Mich.
H & K Machine Service Co., Inc., 6229 Bartmer Ave., St. Louis, Mo.
H. K. Metal Craft Mfg. Corp., 3775 10th Ave., New York, N.Y.
H-P Products, Inc., 510 W Broad St., Louisville, Ohio
H & R Industries, 344 E Walnut St., Nazareth, Pa.
HPL Mfg. Co. (Ad p 350)
15210 Miles Ave., Cleveland 28, Ohio
Haber Corp., 864 W North Ave., Chicago 22, Ill.
Hack, J.H. Mfg. Co., 7049 Lyndon Ave., Detroit 21, Mich.
Hadley Bros.-Uhl Co., 514 Clavary Ave., St. Louis 15, Mo.
Haffner Bros. Co., Hopple St. Central Pkwy., Cincinnati 25, Ohio
Hagstoz, T.B. & Son, 709 Sansom, Philadelphia 6, Pa
Haigh Mfg. Co., 225 E Grand River, Brighton, Mich.
Halex Corp., 26302 W 7 Mile Rd., Detroit 40, Mich.
Hall C.P. Co., 414 S Broadway, Akron 8, Ohio
Hall Mfg. Co., 175 Linden St., Hackensack, N.J.
Haller, Inc., 16580 Northville Rd., Northville, Mich.
Hallstead Foundry, Inc., Main St., Hallstead, Pa.
Hamilton Die Cast, Inc., 240 N B St., Hamilton, Ohio
Hamilton Foundry & Machine Co., 1551 Lincoln Ave., Hamilton, Ohio
Hamilton Watch Co., Precision Metals Div., Lancaster, Pa.
Hampden Brass & Aluminum Co., 262 Liberty St., Springfield, Mass.
Hampton Mfg. Co., 111 Cedar St., New Rochelle, N.Y.
Handy & Harman (Ad p 399)
82 Fulton St., New York 38, N.Y.
Hanford Foundry Co., 119 S Arrowhead Ave., San Bernardino, Calif.

Addresses of Suppliers

Hanlon-Gregory Galvanizing Co., 5515 Butler St., Pittsburgh 1, Pa.
Hanovia Chemical Mfg. Co., 1 Central Ave., East Newark, N.J.
Hansell-Elcock, 485 W 23rd Pl., Chicago 16, Ill.
Harbot Die Casting Corp., 52 E Centre St., Nutley, N.J.
Harcast Co., Inc., 620 E Glenolden Ave., Glenolden, Pa.
Hardinge Mfg. Co., 240 Arch St., York, Pa.
Hardman, H.V. Co., Inc. (Ad p 398)
577 Cortlandt St., Belleville 9, N.J.
Hardy, Charles, Inc., 420 Lexington Ave., New York 17, N.Y.
Hardy Mfg. Corp., W Pearl St., Union City, Ind.
Harnischfeger Corp., 4400 W National Ave., Milwaukee 46, Wis.
Harper, H.M. Co., 8200 Lehigh Ave., Morton Grove, Ill.
Harrington & King Perforating Co., Inc. (Ad p 341)
5671½ Fillmore St., Chicago 44, Ill.
Harris, Benjamin & Co., 11th & State Sts., Chicago Hts., Ill.
Harsco Corp., 3200 Guardian Bldg., Detroit 26, Mich.
Ainsworth-Precision Castings Co. Div., (Ad p 344)
3200 Guardian Bldg., Detroit 26, Mich.
Harshaw Chemical Co., 1945 E 97th St., Cleveland 6, Ohio
Harte & Co., Inc., 16 E 24th St., New York, N.Y.
Hartford Electric Steel Corp., 540 Flatbush Ave., Hartford 10, Conn.
Hartweld Co., 1302 Expressway Dr., Toledo 8, Ohio
Hartwell, H.N. & Son, Inc., Park Square Bldg., 31 St. James St., Boston 16, Mass.
Harvey Machine Co., Inc., Harvey Aluminum Div., 19200 S Western Ave., Torrance, Calif.
Harvill Corp., 6251 W Century Blvd., Los Angeles 45, Calif.
Harvin & Co., Box 83, Federal St., Kenilworth, N.J.
Harwood Screw Products, Inc., 1620 E Pleasant St., Springfield, Ohio
Haskelite Mfg. Corp., 701 Ann St., NW, Grand Rapids, Mich.
Hassall, John Inc., (Ad p 401)
Westbury, Long Island, N.Y.
Hastings & Co., Inc., 2314 Market St., Philadelphia 3, Pa.
Haveg Industries, Inc., 900 Greenbank Rd., Wilmington 8, Del.
Hawkeye Rubber Mfg. Co., 915 Shaver Road NE, Cedar Rapids, Iowa
Hawkridge Bros. Co., 303 Congress St., Boston 10, Mass.
Haws Refractories Co., 407 Main St., Johnstown, Pa.
Hay, James E. Leather Co., 244 Smith St., Lowell, Mass.
Hayden Mica Co., Inc., Main St., Wilmington, Mass.
Hayden Wire Works, Inc., 31 Sylvan St., West Springfield, Mass.
Hayes Adhesive Co., Inc., Union Blvd. at Brown Ave., St. Louis 15, Mo.
Hayman, Michael & Co., 856 E Ferry St., Buffalo 11, N.Y.
Hays Mfg. Co., 80 W 12th St., Erie, Pa.
Haywik Galvanizing Inc., P.O. Box 372, Harvey, La.
Haziedine, E.T. Co., 231 S 1st St., Terre Haute, Ind.
Headford Bros. & Hitchins Foundry Co., 1502 Westfield Ave., Waterloo, Iowa
Headly Mfg. Co., 4376 W Ogden Ave., Chicago 23, Ill.
Heatbath Corp., P.O. Box 78, Springfield 1, Mass.
Heil Process Equipment Corp., 12901 Elmwood Ave., Cleveland 11, Ohio
Heintz Mfg. Co., Front St. & Olney Ave., Philadelphia 20, Pa.
Held, O.P. Inc., 761 Nepperhan Ave., Yonkers 3, N.Y.
Heli-Coil Corp., Shelter Rock Lane, Danbury, Conn.
Heller, A.B. Screw Products, Inc., 14571 Lesure Ave., Detroit 27, Mich.
Heller Tool Co., Heller Dr., Newcomerstown, Ohio
Helmick Foundry-Machine Co., P.O. Box 71, Fairmont, W. Va.
Hendrick Mfg. Co., 50 Dundaff St., Carbondale, Pa.
Henefelt Precision Products, 1630 Herald Ave., Cincinnati 12, Ohio
Henrite Products Corp., Ironton, Ohio
Heppenstall Co., 4620 Hatfield St., Pittsburgh 1, Pa.
Hercules Fastener Co., 2722 N Clybourn St., Chicago 14, Ill.
Hercules Powder Co., Inc., Delaware Trust Bldg., Wilmington 99, Del.
Heresite & Chemical Co., Manitowoc, Wis.
Herker Screw Products, Inc., 4924 N 125th St., Butler, Wis.
Herman Machine & Tool Co., Tallmadge, Ohio
Hersey Metal Products, Inc., Derby, Conn.
Hettleman, K. & Sons, Inc., 9th & Patapsco Aves., Baltimore 25, Md.
Hewitt, John Foundry Co., 15-29 Sherman Ave., East Newark, N.J.
Hewitt-Robins, Inc., 66 Glenbrook Rd., Stamford, Conn.
Hewitt Rubber Div., 240 Kensington Ave., Buffalo, N.Y.
Hexcel Products, Inc., 2741 9th St., Berkeley 10, Calif.
Heypian Mfg. Co., E Michigan Ave., Kenilworth, N.J.
Hibben & Co., 9376 S Ewing Ave., Chicago, Ill.
Hica, Inc., 1431 W 59th St., Shreveport, La.
Hicks Corp., Hyde Park Ave., Boston, Mass.
Higbie Mfg. Co., Avon Tube Div., Klein Rd., Rochester, Mich.
High Vacuum Equipment Corp., 2 Churchill Rd., Hingham, Mass.
Hi-Grade Alloy Corp., 1236 S Talman Ave., Chicago 8, Ill.
Hilfinger Corp., 1800 Westwood Ave., Toledo 7, Ohio
Hills-McCanna Co., 3025 N Western Ave., Chicago 18, Ill.
Hilo Varnish Corp., Industrial Finishes Div., Carpenter-Morton Co., 376 3rd St., Everett 49, Mass.
Himmel Bros. Co., 1409 Dixwell Ave., Hamden, Conn.
Hi-Shear Rivet Tool Co., 2600 W 247th St., Torrance, Calif.
Hitchiner Mfg. Co., Inc., Milford, N.H.
Hitemp Wires, Inc., 1200 Shames Dr., Westbury, N.Y.
Hobart Bros. Co., 1221 Hobart Rd., Troy, Ohio
Hobbs, Clinton E. Co., 203 Chelsea St., Everett 49, Mass.
Hodges, William & Co., Inc., 1627 N American St., Philadelphia 2, Pa.
Hodgman Rubber Co., Tripp St., Framingham, Mass.
Hodgson Foundry Co., 2012 W 13th St., Chicago 8, Ill.
Hoeganaes Sponge Iron Corp., (Ad p 342)
Riverton, N.J.
Hoffman Bronze & Aluminum Casting Co., 1000 Addison Rd., Cleveland 3, Ohio
Hofford Varnish Co., Inc., Broad & 14th Sts., Carlstadt, N.J.
Hohwieler Rubber Co., Inc., 32 W Bridge St., Morrisville, Pa.
Hokin Aluminum Co., 142nd St. & Cottage Grove, Dolton, Ill.
Hollingsworth & Vose Co., Washington St., East Walpole, Mass.
Holt Products Co., Walnut St., Holt, Mich.
Home Rubber Co., 30 Woolverton Ave., Trenton, N.J.
Homestead Valve Mfg. Co., P.O. Box 348 Coraopolis, Pa.
Hommel, O. Co., P.O. Box 475, Pittsburgh 20, Pa.
Hoofer Mfg. Co., 544 W Lake St., Chicago 6, Ill.
Hooker Chemical Corp., 51 47th St., Niagara Falls, N.Y.
Durez Plastics Div., (Ad pp 192-93)
1967 Walck Rd., North Tonawanda, N.Y.
Hoover Co., Die Casting Div., 101 E Maple St., North Canton, Ohio
Hoskins Mfg. Co., 4445 Lawton Ave., Detroit 8, Mich.
Houdaille Industries, Inc., Fairmount Tool & Forging, Inc. Sub., 10611 Quincy Ave., Cleveland 6, Ohio
Houghton, E.F. & Co., 303 W Lehigh Ave., Philadelphia 33, Pa.
Houghton Laboratories, Inc., 322 Houghton Ave., Olean, N.Y.
Houston Blow Pipe & Sheet Metal Works, P.O. Box 1692, Houston 1, Tex.
Howard Foundry Co., 1700 N Kostner Ave., Chicago 29, Ill.
Hoyt, Charles D. Co., Inc., 1118 Forest Ave., Mishawaka, Ind.
Huck Mfg. Co., 2480 Bellevue Ave., Detroit 7, Mich.
Hudson Cush-N-Foam Corp., Lake Ave. & Saw Mill River Rd., Yonkers, N.Y.
Hudson Screw Machine Products Co., 4500 W Augusta Blvd., Chicago 51, Ill.
Hudson Smelting & Refining Co., 567 Wilson Ave., Newark 5, N.J.
Hudson Wire Co., Pequot Wire Cloth Co. Div., 35 Hoyt St., Norwalk, Conn.
Hughes Glue Co., 3500 St. Aubin Ave., Detroit 7, Mich.
Hughes Tool Co., 5425 Polk Ave., P.O. Box 2539, Houston 1, Tex.
Hull, R.O. & Co., Inc., 1300 Parsons Ct., Rocky River 16, Ohio
Humphrey Castings, Inc., 3944 Riley St., San Diego 10, Calif.
Hungerford Plastics Corp., P.O. Box 376, Morristown, N.J.
Hunt Screw & Mfg. Co., 4117 N Kilpatric Ave., Chicago 41, Ill.
Hunter Spring Co., 1 Spring Ave., Lansdale, Pa.
Hunt-Spiller Mfg. Corp., 383 Dorchester Ave., Boston 82, Mass.
Huron Automatic Screw Co., 1401 Water St., Port Huron, Mich.
Huron Forge & Machine Co., 9041 Alpine Ave., Detroit 4, Mich.
Hydrawlik Co., 131-137 E 1st St., Roselle, N.J.
Hydroforming Co. of America, 4700 W Lawrence Ave., Chicago 31, Ill.
Hydrometals, Inc., Illinois Zinc Co. Div., 2959 W 47th St., Chicago 32, Ill.
Hy-Level Screw Products Co., 2615 Scranton Rd., Cleveland 13, Ohio

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I-F Mfg. Co., New Philadelphia, Ohio
Ideal Can Co., 68 Vine St., Everett 49, Mass.
Ideal Metal Products Co., 4842 W Kinzie St., Chicago 44, Ill.
Illinois Forge, Inc., Rock Falls, Ill.
Illinois Iron & Bolt Co., Carpentersville, Ill.
Illinois Precise Casting Co., 903 N Spaulding Ave., Chicago 51, Ill.
Illinois Smelting & Refining Co., 3637 S Albany Ave., Chicago 32, Ill.
Illinois Tool Works, Shakeproof Div., St. Charles Rd., Elgin, Ill.
Imco Container Corp., 75th & Cleveland Sts., Kansas City, Mo.
Impact Extrusions, Inc., 2102 Calumet Rd., Valparaiso, Ind.
Impax, Inc., P.O. Box 5841, Ferguson 21, Mo.
Improved Seamless Wire Co., 775 Eddy St., Providence 5, R.I.
Imsande Screw Products Co., 3517 Cardiff Ave., Cincinnati 9, Ohio
Indar Corp., Indianapolis, Ind.
Independence Stove & Mfg. Co., Haywood & Cottage Sts., Independence, Mo.
Independent Galvanizing Co., 37 Verona Ave., Newark 4, N.J.
Indiana Brass Co., Inc., P.O. Box 113, Frankfort, Ind.
Indiana Forge & Machine Co., 3468 Watling St., East Chicago, Ind.
Indiana Steel Products Co., Valparaiso, Ind.
Indiana Steel & Wire Co., Inc., 700 S Council St., Muncie, Ind.
Indium Corp. of America, (Ad p 133)
1676 Lincoln Ave., Utica 1, N.Y.
Indus Corp., 1815 Madison Ave., Indianapolis 25, Ind.
Industrial Chromium Corp., 109 Lyman St., Holyoke, Mass.
Industrial Equipment Co., 115 Ohio St., Minster, Ohio
Industrial Metal Protectives, Inc., 401 Homestead Ave., Dayton 8, Ohio
Industrial Mica Corp., 223 S Van Brunt St., Englewood, N.J.
Industrial Pipe & Supply Co., 5100 W 16th St., Cicero 50, Ill.
Industrial Plastic Fittings Co., 3891 W 150th St., Cleveland 11, Ohio
Industrial Plastics Corp., 816 W Beardsley Ave., Elkart, Ind.
Industrial Polychemical Service, 17116 S Broadway, Gardena, Calif.
Industrial Precision Products, 325 N Hayne Ave., Chicago 12, Ill.
Industrial Products Suppliers, 201 S Dean St., Englewood, N.J.
Industrial Rayon Corp., 500 5th Ave., New York 36, N.Y.
Industrial Screw Machine Products Co., 1654 W 57th Place, Chicago, Ill.
Industrial Stainless Steels, Inc., 255 Bent St., Cambridge 41, Mass.
Industrial Synthetics Corp., 225 North Ave., Garwood, N.J.
Industrial Tectonics, Inc., 3686 Jackson Rd., Ann Arbor, Mich.
Industrial-Ferguson Foundry Corp., Route 22, Union, N.J.
Ingalls Iron Works Co., 620 4th Ave., Birmingham, Ala.
Ingersoll-Rand Co., Phillipsburg, N.J.
Ingram-Richardson, Inc., 1460 Jefferson Rd., Frankfort, Ind.
Ingram-Richardson Mfg. Co., P.O. Box 191, Beaver Falls, Pa.
Inland Mfg. Co., 1108 Jackson St., Omaha 2, Neb.
Inland Steel Co., 30 W Monroe St., Chicago 3, Ill.
Inshield Die & Stamping Co., 1931 Manhattan Blvd., Toledo 8, Ohio
Inspiration Consolidated Copper Co., 25 Broadway, New York 4, N.Y.
Instrument Parts Corp., Snowden Ave. & Water St., Ossining, N.Y.
Instrument Specialties Co., Inc. (Ad p 343)
244 Bergen Blvd., Little Falls, N.J.

Insulation Mfrs. Corp., 565 W Washington Blvd., Chicago 6, Ill.
Insulation Products Co., P.O. Box 5679, Pittsburgh 8, Pa.
Interchemical Corp., 67 W 44th St., New York 36, N.Y.
Angier Adhesives Div., 120 Potter St., Cambridge 42, Mass.
Finishes Div., 224 McWhorter St., Newark 5, N.J.
Interlake Mfg. Co., 13595 Helen Ave., Detroit 12, Mich.
International Balsa Corp., 100 Boyd Ave., Jersey City 4, N.J.
International Harvester Co., 180 Michigan Ave., Chicago, Ill.
International Minerals & Metals Corp., 11 Broadway, New York 4, N.Y.
International Nickel Co., Inc., (Ad pp 25-8)
67 Wall St., New York 5, N.Y.
International Optical Co., Inc., 47 Urban Ave., Westbury, L.I., N.Y.
International Packings Corp., Bristol, N.H.
International Paper Co., Long-Bell Div., Longview, Wash.
International Powder Metallurgy Co., Inc., 439 W Main St., Ridgway, Pa.
International Silver Co., Eyelet Specialty Div., 50 State St., Waterbury, Conn.
Investment Casting Co., 60 Brown Ave., Springfield, N.J.
Iowa Malleable Iron Co., 9th & Kirkwood Sts., Fairfield, Iowa
Ironton Fire Brick Co., Box 536, Ironton, Ohio
Irvington Form & Tank Corp., 20 Vesey St., New York 7, N.Y.
Irwin Foundry and Mine Car Co., Industrial and Furnace Car Div., Box 311, Irwin, Pa.
Isaacson Iron Works, 8531 E Marginal Way, Seattle 14, Wash.
Isocyanate Products, Inc., 900 Wilmington Rd., New Castle, Del.
Iten Fibre Co., Box 20, Ashtabula, Ohio

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Jackson Auto Radiator, 1515 Altgeld St., Chicago 14, Ill.
Jackson Steel Products, Inc., 32 Rodney St., Brooklyn 11, N.Y.
James Hill Mfg. Co., 20 Gordon Ave., Providence 5, R.I.
Jamestown Finishes, 125 Blackstone Ave., Jamestown, N.Y.
Jamestown Malleable Iron Corp., 3444 Blackstone Ave., Jamestown, N.Y.
Jamison Plastic Corp., 1255 Newbridge Rd., North Bellmore, L.I., N.Y.
Janney Cylinder Co., 7401 State Rd., Philadelphia 36, Pa.
Jaques Co., 67 Batterymarch St., Boston 10, Mass.
Jarco Metal Products, Portland Ave., Westbury, L.I., N.Y.
Jarl Extrusions, Inc. (Ad p 348)
Linden Ave., East Rochester, N.Y.
Jasco Aluminum Products Co., New Hyde Park, N.Y.
Jasper Lacquer Co., Inc., Vine St., Jasper, Ind.
Jelliff, C.O. Mfg. Corp., Pequot Rd., Southport, Conn.
Jelrus Precision Casting Corp., 136 W 52 St., New York, N.Y.
Jema Chemical & Supply Co., 190 South St., Newark, N.J.
Jersey Plastic & Die Casting Co., 151 Shaw Ave., Irvington, N.J.
Jet Components, Inc., 3142 San Fernando Rd., Los Angeles, Calif.
Jet Specialties Co., Inc., 941 N Eastern Ave., Los Angeles, Calif.
Ill.
Jobbins, William F. Inc., Aurora,
Johns-Manville Corp., 22 E 40th St., New York 16, N.Y.
Dutch Brand Div., 7800 Woodlawn Ave., Chicago 19, Ill.
Johnson, A. & Co., Inc., 21 West St., New York 6, N.Y.
Johnson Bronze, S Mill St., New Castle 6, Pa.
Johnson Metal Hose, Inc., 10 Sperry St., Waterbury 20, Conn.
Johnson Plastic Corp., Box 312, Chagrin Falls, Ohio
Johnson Rubber Co., 111 Vine St., Middlefield, Ohio
Johnson, S.C. & Son, Inc., Racine, Wis.
Johnson Steel and Wire Co., Inc., 53 Wiser Ave., Worcester, Mass.
Johnston Foil Mfg. Co., 6106 S Broadway, St. Louis 11, Mo.
Johnston & Funk Titanium Corp., W Kemrow Ave., Wooster, Ohio
Johnstone Foundries, Inc., P.O. Box 549, Grove City, Pa.
Jolens Metal Products Co., 224 Sussex Ave., Newark 4, N.J.
Jones & Laughlin Steel Corp., 3 Gateway Center, Pittsburgh 30, Pa.
Stainless Steel Div., (Ad p 73)
21400 Mound Rd., P.O. Box 4606, Detroit 34, Mich.
Strip Steel Div., 1939 Teeghly St., Youngstown 1, Ohio
Jordan Co., 51st St. & Merrimac Ave., Chicago 38, Ill.
Jordan Machine Products, Inc., 3611 St. Aubin Ave., Detroit 7, Mich.
Jordan-Rogers Co., 640 N Cypress, Orange, Calif.
Joseff-Hollywood Co., 129 E Providencia, Burbank, Calif.
Joslyn Mfg. & Supply Co., 155 N Wacker Dr., Chicago 6, Ill.
Joslyn Pacific Co., 5100 District Blvd., Los Angeles 11, Calif.
Joslyn Stainless Steels, 155 N Wacker Dr., Chicago 6, Ill.
Joymont Plastics, Inc., 710 S State St., Girard, Ohio
Judd Industries, Inc., 3148 W 32 St., Cleveland 9, Ohio
Judsen Rubber Works, Inc., 4107 W Kinzie St., Chicago 24, Ill.

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K-D Mfg. Co., 435 Shaffer St., Cleburne, Tex.
K. & L. Plating Co., 535 E Mifflin St., Lancaster, Pa.
K S H Plastics, Inc., Hwy. 30, High Ridge, Mo.
Kaiser Aluminum & Chemical Sales Inc., (Ad pp 334-5)
919 Michigan Ave., Chicago 11, Ill.
Kaiser Steel Corp., 1924 Broadway, Oakland 12, Calif.
Kamin Die Casting & Mfg. Co., 3315 N Knox, Chicago 41, Ill.
Kanawha Mfg. Co., Charleston, W. Va.
Kansas City Hay Press Co., 801 Weeswether Rd., Kansas City 5, Mo.
Kanthal Corp., Amelia Pl., Stamford, Conn.
Katelman Foundry & Mfg. Co., 238 S 11th St., Council Bluffs, Iowa
Kawecki Chemical Co., 220 E 42nd St., New York 17, N.Y.
Kawneer Co., 1105 N Front St., Niles, Mich.
Kay-Bee Machine Products Co., 2776 S 34 St., Milwaukee 15, Wis.
Kay-Brunner Steel Products, Inc., 999 Meridian Ave., Alhambra, Calif.
Kaye-Tex Mfg. Corp., Kaykor Industries, Inc. Div., Yardville, N.J.
Keasbey & Mattison Co., Butler Ave., Ambler, Pa.
Keen Foundry Co., Inc., E Main & E Jerr Sts., Griffith, Ind.
Kees, F.D. Mfg. Co., 700 Park St., Beatrice, Neb.
Kelite Corp., Bldg. 15, 81 Industrial Rd., Berkeley Heights, N.J.
Keller Products, Inc., 37 Union, Manchester, N.H.
Kelley Mfg. Co., 4800 Clinton Dr., P.O. Box 17, Houston 1, Tex.
Kelly Foundry Co., 1704 Wharton St., Pittsburgh 3, Pa.
Kelsey-Hayes Co., Utica Metals Div., Utica 4, N.Y.
Kendall Co., Walpole, Mass.
Kendall Mills Div., Walpole, Mass.
Polyken Sales Div., 309 W Jackson Blvd., Chicago 6, Ill.
Kenmore Machine Products, Inc., 15 Depew Ave., Lyons, N.Y.
Kennametal, Inc., (Ad p 255)
Lloyd Ave., Latrobe, Pa.
Kennedy Automatic Products, Inc., 406 S Linden St., Marshall, Mich.
Kenosha Automatic Products Co., 3919 13th Ave., Kenosha, Wis.
Kensico Tube Co., Hubbell & RR Aves., Mt. Kisco, N.Y.
Kent Castings Corp., 200 Garden St., Grand Rapids 7, Mich.
Kent County Galvanizing Co., 15 Earlham Way, Hillsgrove 5, R.I.
Keolyn Plastics, Inc., 2731 N Pulaski Rd., Chicago 39, Ill.
Kerr, R.W. Plastic Co., 220 S Burlington Ave., Hastings, Neb.
Kerr-Lakeside Industries, Inc., 21850 St. Clair Ave., Cleveland 17, Ohio
Kester Solder Co., 4201 Wrightwood Ave., Chicago 39, Ill.
Kewaunee Engineering Corp., N Main St., Kewaunee, Wis.
Keystone Carbon Co., 1935 State St., St. Marys, Pa.
Keystone Drawn Steel Co., Main & Bridge Sts., Spring City, Pa.
Keystone Forging Co., Northumberland, Pa.
Keystone Plastics, Inc., 2331 Morris Ave., Union, N.J.
Keystone Refining Co., Inc., Garden St., Philadelphia 37, Pa.
Keystone Steel & Wire Co., Peoria 7, Ill.
Kicknaefer Mfg. Co., 901 S 2nd St., Milwaukee 4, Wis.
Kidd Drawn Steel Co., Aliquippa, Pa.
King, Alfred B. Co., Devine St., North Haven, Conn.
King Laboratories, Inc., 127 Solar St., Syracuse 3, N.Y.
King-Seeley Corp., 720 Norris St., Ypsilanti, Mich.
Kingsport Foundry & Mfg. Corp., E Sullivan & Main Sts., Kingsport, Tenn.
Kinkead Industries, Inc., 5860 N Pulaski Rd., Chicago 30, Ill.
Kirchhof Patent Co., Inc., Dietze Bldg., 60-64 Union St., Newark 5, N.J.
Kirk, F.J. Co., Inc., 140 Brook St., Clinton, Mass.
Kirk, Morris P. & Son, 2700 S Indiana St., Los Angeles 23, Calif.
Kish Industries, Inc., 1301 N Turner St., Lansing 6, Mich.
Kleiner Metal Specialties, Inc., P.O. Box 185, Dunellen, N.J.
Klincher Locknut Corp., 2153 Hillside Ave., Indianapolis 18, Ind.
Kling Metal Spinning & Stamping Co., 245-247 Centre St., New York 13, N.Y.
Klinzing, A.F. Co., Inc., 921 A 2nd St., Milwaukee 4, Wis.
Klise Mfg. Co., 50 Cottage Grove St., Grand Rapids 2, Mich.
Knapp Mills, Inc., 23-17 Borden Ave., Long Island City 1, N.Y.
Knight, Maurice A., 171 Kelly Ave., Akron 9, Ohio
Knoedler Chemical Co., 651 High St., Lancaster, Pa.
Knowlton Bros., Inc., (Ad p 246)
215 Factory, Watertown, N.Y.
Kobel, W.R. Sheet Metal Products, 148 W 21st St., Ogden, Utah
Koch, H. & Sons, P.O. Box 125, Corte Madera, Calif.
Koehler Mfg. Co., 395 Lincoln St., Marlboro, Mass.
Koehring Co., Milwaukee, Wis.
Kohn Engineering Corp., 8830 S Telegraph Rd., Taylor Center, Mich.
Koppers Co., Inc., Chemical Div., Koppers Bldg., Pittsburgh 19, Pa.
Korhumel Steel and Aluminum Co., 2424 Oakton St., Evanston, Ill.
Koster-Keunen Mfg. Co., Inc., Bourne Blvd., Sayville, N.Y.
Kovar, John R. Mfg. Co., Inc., Bridge Square, Anoka, Minn.
Koven, L.O. & Brother, Inc., 154 Ogden Ave., Jersey City 7, N.J.
Kralay Plastic Pipe Co., Inc., 4710-20 E Washington Blvd., Los Angeles 22, Calif.
Kramer, C.P. Co., 9230 W Belmont Ave., Franklin Park, Ill.
Kramer, H. Co., Ajax Metal Div., 46 Richmond St., Philadelphia 23, Pa.
Kramer Bros. Foundry Co., 17 Dell St., Dayton 4, Ohio
Kraus Research Labs, Cockeysville, Md.
Kroh Wagner, 2331 N Pulaski Rd., Chicago 39, Ill.
Krone, Paul Die Casting Co., 1811 N Kostner Ave., Chicago 39, Ill.
Kroppe Forge Co., 5301 W Roosevelt Rd., Chicago 50, Ill.
Krueger Fabricating Co., Inc., 257 W Badger Road, Madison 5, Wis.
Krueger & Hudepohl, Inc., 1041 Evans St., Cincinnati 4, Ohio
Kuhn & Jacob Molding & Tool Co., 1200 Southard Ave., Trenton 8, N.J.
Kurz Kasch, Inc., 1421 S Broadway, Dayton 1, Ohio
Kuss, R.L. & Co., Inc., 739 Foulke Ave., Findlay, Ohio
Kutztown Foundry & Machine Corp., Kutztown, Pa.
Kwikset Powdered Metal Products, 516 E Santa Ana St., Anaheim, Calif.

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L. O. F. Glass Fibers Co., 1810 Madison Ave., Toledo 1, Ohio
Corrulux Div., 410 Holmes Rd., P.O. Box 20026, Houston 25, Tex.
Laboratory Equipment Corp., Hilltop Rd. & Lakeview Ave., St. Joseph, Mich.
Laclede Steel Co., 1380 Arcade Bldg., St. Louis 1, Mo.
Laconia Malleable Iron Co., 71 Water St., Laconia, N.H.
Lacquer Products, Inc., 9001 Kinsman Rd., Cleveland 4, Ohio
Ladish Co., 5481 S Packard Ave., Cudahy, Wis.
La France Precision Casting Co., 29th & McKean St., Philadelphia 45, Pa.
Lake City Malleable Co., 5000 Lakeside Ave., Cleveland 14, Ohio
Lake Erie Foundry Co., 143 Fillmore Ave., Buffalo 10, N.Y.
Lake Mfg. Corp., 1070 East St., New Britain, Conn.
Lakeland Industries, Isle, Minn.
Lakeside Bronze, Inc., 90 Arthur St., Buffalo 7, N.Y.
Lakeside Malleable Casting Co., 1333 23rd St., Racine, Wis.
Lakewood Metal Products, Inc., 39 Cherry Ave., Waterbury 20, Conn.

Addresses of Suppliers

Laminated Plastex Corp., 1427 W North St., Springfield, Ohio

Laminated Shim Co., (Ad pp 340-41)
1600 Union St., Glenbrook, Conn.

Laminated Veneers Co., 102nd St. & 92nd Ave., Richmond Hill, N.Y.

Lamson Products Co., 1228 Poplar Pl., Seattle 44, Wash.

Lamson & Sessions Co., 5000 Tiedeman Rd., Cleveland 9, Ohio

Lamtex Industries, Inc., 51 State St., Westbury, L.I., N.Y.

Lancaster Glass Corp., 220 W Main St., Lancaster, Ohio

Lancaster Malleable Castings Co., 1170 Lititz Ave., Lancaster, Pa.

Landau, J. & Co., Inc., Carlstadt, N.J.

Lang-Scharmann & Co., 206 W 1st St., Marshfield, Wis.

Langsenkamp, F.H. Co., 229 E South St., Indianapolis, Ind.

Langsenkamp-Wheeler Brass Works, Inc., South & Harmon Sts., Indianapolis, Ind.

Lansdale Porcelain Enamel Corp., 5th & Iron, Lansdale, Pa.

La Porte Foundry Co., 301 Truesdell Ave., La Porte, Ind.

Larkin Specialty Mfg. Co., 915 Linden Ave., South San Francisco, Calif.

Larson, W.O. Foundry Co., 799 Barchard, Grafton, Ohio

Larson, Charles E. & Sons, Inc., 2645-65 N Keeler Ave., Chicago 39, Ill.

Larson Tool & Stamping Co., Olive St., Attleboro, Mass.

La Salle Steel Co., P.O. Box 6800-A, Chicago 80, Ill.

Latrobe Steel Co., Latrobe, Pa.

Lattimer Foundry and Machine Co., Lattimer Mines, Pa.

Lattner Bros. Machining Co., 650 E Troy, Ferndale 20, Mich.

Latwaitis, Ernest A., 102-09 Remsen Pl., Howard Beach 14, N.Y.

Lavin, R. & Sons, Inc., 3426 S Kedzie Ave., Chicago 23, Ill.

Lawrence, L. Co., Inc., 292 Halsey St., Newark 2, N.J.

Lawrence Copper & Bronze Co., W New Castle St., Zilenpole, Pa.

Lawrence Laboratory, 1668 Euclid St., Santa Monica, Calif.

Lawrenceville Screw Co., 4920 Harrison St., Pittsburgh 1, Pa.

Lawson, F.H. Co., Evans & Whateley Sts., Cincinnati 4, Ohio

Lawton, C.A. Co., Broadway, DePere, Wis.

Laystrom Mfg. Co., 20001-17 N Parkside Ave., Chicago 39, Ill.

Lea Mfg. Co., 16 Cherry Ave., Waterbury 20, Conn.

Leach & Garner Co., Industrial Div., Leach & Garner Bldg., Attleboro, Mass.

Leader Iron Works, Inc., 2108 N Jasper St., Decatur, Ill.

Leake Engineering Co., P.O. Box 715-MS, Monroe, Mich.

Lebanon Steel Foundry, 1st Ave. & E Lehmen St., Lebanon, Pa.

LeBarch, E.L. Foundry, Box 746 Brockton, Mass.

Lee Bros. Foundry Co., Inc., P.O. Box 231 Anniston, Ala.

Lee Rubber & Tire Corp., Hector St., Conshohocken, Pa.
Republic Rubber Div., 1410 Albert, Youngstown 1, Ohio

Leed, H.A. Co., 1685 Diswell Ave., Hamden, Conn.

Lehigh, Inc., 1500 Lehigh Dr., Easton, Pa.
Lehigh Foundries Div., 1500 Lehigh Dr., Easton 1, Pa.

Lehigh Structural Steel Co., Allentown, Pa.

Leitelt Bros., Inc., 7721-31 S Chicago Ave., Chicago 19, Ill.

Lenape Hydraulic Pressing & Forging Co., (Ad p 354)
Box 536, West Chester, Pa.

Lester Castings Inc., Cannon & Aurora Rds., Bedford Heights, Ohio

Letukas Foundry, Upland, Ind.

Levinson Steel Co., S 20th & Wharton St., Pittsburgh 3, Pa.

Lewin-Mathes Co., 1111 Chouteau Ave., St. Louis 2, Mo.

Lewis, G.B. Co., (Ad p 336)
4026 Montgomery St., Watertown, Wis.

Lewis, J.P. Co., Plastic Products Div., Beaver Falls, N.Y.

Lewis Bolt & Nut Co., 504 Malcolm Ave. SE, Minneapolis 14, Minn.

Lewis & Saunders, Lakeport, N.H.

Lewistown Foundry & Machine Co., 16 Elizabeth St., Lewistown, Pa.

Liberty Foundry Co., 7600 Vulcan St., St. Louis 11, Mo.

Light Metals Corp., 1211 Monroe Ave. NW, Grand Rapids, Mich.

Light Metals, Inc., 1100 E 24th St., Indianapolis 5, Ind.

Lignum-Vitae Products Corp., 98 Boyd Ave., Jersey City 4, N.J.

Lincoln Electric Co., 22801 St. Clair Ave., Cleveland 17, Ohio

Lincoln Foundry Corp., 2525 E 49th St., Los Angeles 58, Calif.

Lincoln Iron Works, 255 West St., Rutland, Vt.

Lincoln Machine Parts Corp., 732 E 144th St., New York 54, N.Y.

Lincoln Mfg. Co., Inc., 2617 W Fletcher St., Chicago 18, Ill.

Lincoln Steel Corp., 315 W 9th St., Lincoln 1, Neb.

Lindell Drop Forge Co., 2830 S Logan Blvd., Lansing 3, Mich.

Linden & Co., 80 Baker St., Providence 5, R.I.

Linderme Tube Co., 1500 219th St., Cleveland 17, Ohio

Link-Belt Co., Prudential Plaza, Chicago 1, Ill.

Linton Precision Casting Co., 917 N Nappanee St., Elkhart, Ind.

Litemetal Dicast, Inc., 1927 Wildwood Ave., Jackson, Mich.

Lithcote Corp., 5000 W Lake St., Melrose Park, Ill.

Lithium Corp. of America, Inc., (Ad p 124)
400 2nd Ave. S, Minneapolis 1, Minn.

Litho-Strip Corp., M. M. Young Div., 4800 S Kilbourn Ave., Chicago 32, Ill.

Littite Foundries, Inc., 2431 Conners St., Port Huron, Mich.

Little Falls Alloys, Inc., 189 Caldwell Ave., Paterson, N.J.

Littlestown Hardware & Foundry Co., Inc., Charles St., Littlestown, Pa.

Livingston-Tyler Products, 501 N 5th St., Hamilton, Ohio

Lloyd & Scott Brass Foundry, Inc., 2206 Tatnall St., Wilmington 99, Del.

Lock Joint Tube Co., Inc., 1400 Riverside Dr., South Bend 24, Ind.

Locke Machine Co., 971 E 63rd St., Cleveland 3, Ohio

Lockhart Iron & Steel Co., River Ave., McKees Rocks, Pa.

Lockport Mfg. Co., 1102 Collins St., Joliet, Ill.

Lockport Steel Fabricators, Inc., P.O. Box 67, Lockport, Ill.

Lodge Mfg. Co., RR & 6th, South Pittsburgh, Pa.

Lodi Iron Works, Inc., 820 S Sacramento, Lodi, Calif.

Loeffler, J.M. Co., Machine & Brass Works, 149 N 4th St., Philadelphia 6, Pa.

Loewenthal Metals Corp., 947 Cullerton St., Chicago 8, Ill.

Lone Star Plastics Co., Inc., (Ad p 356)
124 Roberts Cutoff, Fort Worth, Tex.

Long Beach Iron Works, 2100 W Anaheim St., Long Beach 13, Calif.

Long Foundry Co., Hoquiam, Wash.

Lorain Automatic Screw Machine Co., Inc., 218 Connecticut, Lorain, Ohio

Lorain Brass Co., 639 Broadway, Lorain, Ohio

Loranger Mfg. Corp., 12-38 Clark St., Warren, Pa.

Lord Mfg. Co., Special Products Div., 1635 W 12th St., Erie, Pa.

Los Angeles Galvanizing Co., Vernon Branch, P.O. Box 58411, Los Angeles 58, Calif.

Los Angeles Steel Casting Co., 6100 S Boyle Ave., Los Angeles 58, Calif.

Loven Chemical of California, 23874 N Pine St., Newhall, Calif.

Lowe Bros. Co., 424 E 3rd St., Dayton 2, Ohio

Lubenow, Arthur Co., 2015 S Kinnickinnic Ave., Milwaukee 7, Wis.

Lucas-Milhaupt Engineering Co., 5051 S Lake Dr., Cudahy, Wis.

Ludlow Valve Mfg. Co., Inc., Hudson River at Adams St., Troy, N.Y.

Lukens Steel Co., (Ad pp 66-7)
Coatesville, Pa.

Lumen Bearing Co., 197 Lathrop St., Buffalo 12, N.Y.

Luminous Resins, Inc., 166 W Washington St., Chicago 2, Ill.

Lundberg Screw Products Co., 2101 W Willow St., Lansing 4, Mich.

Lundquist Tool & Mfg. Co., Inc., 57 Jackson St., Worcester 8, Mass.

Lunn Laminates, Inc., Oakwood & W 11th Sts., Huntington Station, N.Y.

Luria Engineering Co., 1745 Easton Ave., Bethlehem, Pa.

Lus-Trus Corp., 884 Railroad St., Ypsilanti, Mich.

Luthi, F.C. & Co., Balter Bldg., New Orleans, La.

Lux Clock Mfg. Co., Inc., 95 Johnson St., Waterbury 20, Conn.

Luzerne Rubber Co., Muirhead Ave., Trenton 7, N.J.

Lynchburg Foundry Co., Castings Div., Courtland Bldg., Lynchburg, Va.

Lyndon Machine Products Co., Inc., 18564 Fitzpatrick Ave., Detroit 28, Mich.

Lynn Casting Corp., 2609 N San Fernando Blvd., Burbank, Calif.

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M & S Mfg. Co., 220 Main St., Hudson, Mich.

Maas & Waldstein Co., 2121 McCarter Hwy., Newark 2, N.J.

Macaulay, H.C. Foundry Co., 811 Carlton St., Berkeley 10, Calif.

MacDermid Inc., 526 Huntingdon Ave., Waterbury 20, Conn.

Machine Products Corp., 125 Hollier Ave., Dayton, Ohio

Machinery Forging Co., 5430 Hamilton Ave., Cleveland 14, Ohio

Machinery Products Corp., 2020 N Major Ave., Chicago 39, Ill.

Machinery Products Co. of Lancaster, 317 E Fulton St., Lancaster 10, Pa.

Mac-It Parts Co., 275 E Liberty St., Lancaster, Pa.

Mack Molding Co., Wayne, N.J.

MacKenzie-Walton Co., 478 Pawtucket Ave., Pawtucket, R.I.

Macwhyte Co., 2906 14th Ave., Kenosha, Wis.

Madison Foundry Co., 935 Addison Rd., Cleveland 3, Ohio

Madison Kipp Corp., 201 Waubesa St., Madison 10, Wis.

Magic Chemical Co., 121 Crescent St., Brockton 2, Mass.

Magic Iron Cement Co., 5403 Bower Ave., Cleveland 27, Ohio

Magirl Foundry & Furnace Co., 413 E Oakland Ave., Bloomington, Ill.

Magline, Inc., 1960 Mercer, Pinconning, Mich.

Magna Mfg. Co., Inc., 4th Ave., Haskell, N.J.

Magnesium Co. of America, 5222 Indianapolis Blvd., East Chicago, Ill.

Magnesium Elektron, Inc., 630 5th Ave., New York 20, N.Y.

Magnesium Products of Milwaukee, Inc., 748 W Virginia St., Milwaukee 4, Wis.

Magnetic Core Corp., John & Lawrence Sts., Newburgh, N.Y.

Magnetic Powders, Inc., Fairview Ave., Johnsonburg, Pa.

Magnetic Stamping Co., Fairview Ave., Johnsonburg, Pa.

Magnode Products, Inc., P.O. Box 292, Trenton, Ohio

Magnuson Products Corp., 50 Court St., Brooklyn 1, N.Y.

Mahon, R.C. Co., 6565 E 8 Mile Rd., Detroit 34, Mich.

Main Screw Machine Products, Inc., 58 Lafayette St., Waterbury, Conn.

Malleable Iron Fittings Co., Branford, Conn.

Mallory, P.R. & Co., Inc., 3033 E Washington St., Indianapolis 6, Ind.

Mallory-Schwarzkopf Metals, Inc., 320 Yonkers Ave., Yonkers, N.Y.

Mallory-Sharon Metals Corp., (Ad p 137)
980 Warren Ave., Niles, Ohio

Malone Bronze Powder Works, Inc., Malone, N.Y.

Malone Metal Powders, Inc., Rte. 202, Flemington, N.J.

Maloney, F.H. Co., 2301 Texas Ave., P.O. Box 1777, Houston 1, Tex.

Malvern Brick & Tile Co., P.O. Box 415 Malvern, Ark.

Manco Products, Inc., 2401 Schaefer Rd., Melvindale, Mich.

Manganese Steel Forge Co., Richmond St. & Castor Ave., Philadelphia 34, Pa.

Manhattan Adhesives Corp., 425 Greenpoint Ave., Brooklyn 22, N.Y.

Mannesmann-Easton Plastic Products Co., Inc., 900 Line St., Easton, Pa.

Manor Die Cast Corp., P.O. Box 386, Bedford, Ohio

Mansfield Brass & Aluminum Corp., 287 N Diamond St., Mansfield, Ohio

Mansol Ceramics Co., 140 Little St., Belleville 9, N.J.

Mantel Screw Products Co., 3200 W Vliet St., Milwaukee 8, Wis.

Manufacturers Corp., 104 Ausdale Ave., Mansfield, Ohio

Manufacturers & Fabricators, Inc., Filbert St., Elyria, Ohio

Manufacturers Iron Foundry, Inc., 785 Union Ave., Bridgeport, Conn.

Manufacturers Service, Inc., 11440 Brookpark Rd., Cleveland 30, Ohio

Marblette Corp., 37-31 30th St., Long Island City 1, N.Y.

Markal Co., 3052 W Carroll Ave., Chicago 12, Ill.

Mariane Development Co., Inc., 153 E 26th St., New York 10, N.Y.

Marquette Mfg. Co., Inc., 307 E Hennepin Ave., Minneapolis, Minn.

Marquette Metal Products Co., 1145 Galewood Dr., Cleveland 10, Ohio

In contacting suppliers, please mention the Materials Selector

Marsco Mfg. Co., 2901 S Halsted St., Chicago 8, Ill.
Marshall Car Wheel & Foundry Co., Inc., 605 Greenwood Ave., Marshall, Tex.
Martin Rubber Co., Inc., Long Branch Ave., Long Branch, N.J.
Masco Screw Products Co., 12825 Ford Rd., Dearborn, Mich.
Masland Duraleather Co., Amber & Willard Sts., Philadelphia 34, Pa.
Mason Envelope Co., Inc., 536 Broadway, New York 12, N.Y.
Masonite Corp., 111 W Washington St., Chicago 2, Ill.
Massachusetts Screw Mfg. Co., 9 W 3rd St., South Boston 27, Mass.
Massillon Steel Casting Co., Box 388, Massillon, Ohio
Master Chrome Service, Inc., 5709 Herman Ave., Cleveland 2, Ohio
Matthiessen & Hegeler Zinc Co., 9th & Sterling Sts., La Salle, Ill.
Maumee Machine & Tool Corp., 2501 Lagrange St., Toledo 8, Ohio
May, Inc., 5803 Alice Rd., Houston 5, Tex.
Maynard Mfg. Co., 22755 Shakespeare Ave., East Detroit, Mich.
Mayon Plastics, 415 17th Ave. N, Hopkins, Minn.
Mayville Metal Products Co., 104 Highland St., Mayville, Wis.
Maze, W.H. Co., 1207 Water St., Peru, Ill.
McCarter Iron Works, Inc., Norristown, Pa.
McCrady Refractories, Inc., P.O. Box 11566, Pittsburgh 38, Pa.
McDanel Refractory Porcelain Co., (Ad p 252)
510 9th Ave., Beaver Falls, Pa.
McDougall Butler Co., Inc., 2929 Main St., Buffalo 14, N.Y.
McDowell Mfg. Co., 301 Stanton Ave., Pittsburgh 9, Pa.
McGean Chemical Co., 1040 Midland Bldg., Cleveland 15, Ohio
McGraw-Edison Co., 5201 W 65th St., Chicago, Ill.
Illinois Edison Porcelain Div., Macomb, Ill.
Line Material Industries Div., N Burson St., East Stroudsburg, Pa.
Mc Gregor-Michigan Corp., 5818 Rivard, Detroit 11, Mich.
McInnes Steel Co., 441 E Main St., Corry, Pa.
McKay Co., 481 McKay Bldg., Pittsburgh, Pa.
McKinney Mfg. Co., 1715 Liverpool St., Pittsburgh 33, Pa.
McLanahan & Stone Corp., 200 Wall St., Hollidaysburg, Pa.
McLouth Steel Corp., 300 S Livernois Ave., Detroit 17, Mich.
McMahon Bros. Machine Works, Inc., 3200 S 61st Court, Cicero 50, Ill.
McNally Pittsburg Mfg. Co., P.O. Drawer D., Pittsburg, Kan.
Meaden Screw Products Co., 3010 S Kilbourn Ave., Chicago 23, Ill.
Meadville Malleable Iron Co., Meadville, Pa.
Mearl Corp., 124 E 40th St., New York 16, N.Y.
Measuregraph Co., 4245 Forest Park Blvd., St. Louis 8, Mo.
Mechanical Art Works, Inc., 96-98 Monroe St., Newark 5, N.J.
Mechanical Felt & Textiles Co., 50 W 18th St., Weehawken, N.J.
Mechanical Leathers, Inc., 2204 E Butler St., Philadelphia 37, Pa.
Mechanical Plating Co., 1500-26 W Hubbard St., Chicago 22, Ill.
Mechanical Rubber Products Co., Warwick, N.Y.
Mechanical Steel Tubing Corp., 500 Barry St., New York 59, N.Y.
Medico Industries, Inc., 11-13 Tompkins St., Pittston, Pa.
Meehanite Metal Corp., 714 North Ave., New Rochelle, N.Y.
Meeker Foundry Co., Newark 4, N.J.
Meier Screw Products & Mfg. Co., 19361 Sherwood Ave., Detroit, Mich.
Melco Wire Products, 4407 San Fernando Rd., Glendale 4, Calif.
Melling Forging Co., 1709 Thompson St., Lansing 3, Mich.
Melray Mfg. Co., 9240 Chestnut Ave., Franklin Park, Ill.
Mercast Mfg. Corp., 2620 1st St., La Verne, Calif.
Merit Screw Machine Products Co., Inc., 4847 W Lake St., Chicago 44, Ill.
Merit Specialties Co., Inc., 203-205 E Davis St., St. Louis 11, Mo.
Merix Chemical Co., 1021 E 55th St., Chicago 15, Ill.
Merrimac Brass, 22 High St., Merrimac, Mass.
Merriman Bros., Inc., 185 Amory St., Boston 30, Mass.
Merz Machine & Tool Works, 920 N Main St., Crown Point, Ind.
Mesa Plastics Co., 11751 Mississippi St., Los Angeles 25, Calif.
Metal Coating Corp., 1215 W 37th St., Chicago 9, Ill.
Metal Finishers, Inc., 78 S Franklintown Rd., Baltimore 23, Md.
Metal Forming Corp., 1937 Sterling Ave., Elkhart, Ind.
Metal Goods Corp., 6211 Cedar Springs Rd., Dallas 35, Tex.
Metal Goods Corp., 8800 Page Blvd., St. Louis 14, Mo.
Metal Hydrides, Inc., 12 Congress St., Beverly, Mass.
Metal Mold Magnesium Corp., 95 Hamilton St., Cedarburg, Wis.
Metal Parts & Stamping Co., 1120 Eastern Ave., Cincinnati, Ohio
Metal Textile Corp., Mist Eliminator Div., 647 E 1st Ave., Roselle, N.J.
Metal Trims, Inc., Livingston Rd., Jackson, Miss.
Metal & Thermit Corp., Woodbridge Ave. at Randolph Ave., Rahway, N.J.
Metal-Cladding, Inc., P.O. Box 544, North Tonawanda, N.Y.
Metallized Carbon Co., 19 S Water St., Ossining, N.Y.
Metallizing Co. of America, 3520 W Carroll Ave., Chicago 24, Ill.
Metallizing Co. of Los Angeles, Inc., 1233 S Boyle Ave., Los Angeles 23, Calif.
Metallizing Engineering Co., Inc. (Ad pp 128, 280, 291)
Prospect Ave., Westbury, N.Y.
Metallurgical Products Co., 35th & Moore Sts., Philadelphia, Pa.
Metalplate Co., Inc., 757 North 44th St., Birmingham 6, Ala.
Metals & Controls Corp., General Plate Div., 50 Forest St., Attleboro, Mass.
Metals Disintegrating Co., P.O. Box 290, Elizabeth, N.J.
Metalweld, Inc., Protective Coating Div., Scotts Lane & Abbottsford Ave., Philadelphia, Pa.
Metaplast Process, Inc., 34-51 56th St., Woodside, N.Y.
Met-L-Wood Corp., 6755 W 65th St., Chicago 38, Ill.
Metropolitan Iron Foundry, 890 Metropolitan Ave., Brooklyn 11, N.Y.
Meyer, J. & Sons, Inc., 4321 N 4th St., Philadelphia 40, Pa.
Mica Fabricating Co., 53 Central Ave., Rochelle Park, N.J.
Micacraft Products, Inc., 701 Mo-Carter Hwy., Newark, N.J.
Michelman Chemicals, Inc., 6316 Wiehee Rd., Cincinnati, Ohio
Michigan Chrome & Chemical Co., 8615 Grinnell Ave., Detroit 13, Mich.
Michigan Leather Products Co., 6307 E Lafayette Ave., Detroit 7, Mich.
Michigan Plastic Products, Inc., Robbins Rd., Grand Haven, Mich.
Michigan Powdered Metal Products Co., 456 E Cady St., Northville, Mich.
Michigan Seamless Tube Co., South Lyon, Mich.
Michigan Wire Cloth Co., 2100 Howard St., Detroit 16, Mich.
Mico Corp., 4031 Elenda, Culver City, Calif.
Micro Metallic Corp., 30 Sea Cliff Ave., Glen Cove, N.Y.
Micro Products Corp., 4116-18 Olive St., St. Louis 8, Mo.
Micro-Metals Co., 52 E Montecito Ave., Sierra Madre, Calif.
Midland Adhesive & Chemical Corp., 2600 Goodrich, Ferndale 20, Mich.
Midland Industrial Finishes Co., (Ad p 285)
E Water St., Waukegan, Ill.
Midland Pipe & Supply Co., 2829 S 61st St., Cicero 50, Ill.
Mid-States Rubber Products, Inc., 1230 Race St., Princeton, Ind.
Mid-States Steel & Wire Co., Crawfordsville, Ind.
Midvale-Heppenstall Co., Nicetown, Philadelphia 40, Pa.
Midwest Molding & Mfg. Co., Gurnee, Ill.
Midwest Piping Co., Inc., 2nd & Barry Sts., St. Louis 4, Mich.
Midwest Plastic Products Co., 1801 Chicago Rd., Chicago Heights, Ill.
Midwest Precision Castings Co., 1070-903 Quincy Ave., Cleveland 6, Ohio
Mid-West Screw Products Co., 3662 Park Ave., St. Louis 10, Mo.
Midwest Screw Products, Inc., 1641 Coit Ave., East Cleveland 12, Ohio
Midwest Sintered Products Corp., 13606 S Halsted St., Chicago 27, Ill.
Midwest Stamping & Mfg. Co., Krauss Rd., Bowling Green, Ohio
Mid-West Wire Products Co., Inc., 2555 Fenkell Ave., Detroit 38, Mich.
Midwestern Foundries, Inc., 614 E Quincy, Garrett, Ind.
Milford Automatics, Inc., 1553 Boston Post Rd., Milford 15, Conn.
Milford Rivet & Machine Co., Milford, Conn.
Milled Screw Product Co., 2016-2026 W Lake St., Chicago 12, Ill.
Miller Co., 99 Centre St., Meriden, Conn.
Millers' Brass Fitting Co., Inc., 30 Main St., Brooklyn 1, N.Y.
Milwaukee Aluminum & Brass Foundry, 643 S 2nd St., Milwaukee 4, Wis.
Milwaukee Die Casting Co., 4134 N Holton St., Milwaukee 12, Wis.
Milwaukee Forge & Machine Co., 1532 E Oklahoma Ave., Milwaukee 7, Wis.
Milwaukee Machine Products Co., 3889 N 1st St., Milwaukee 12, Wis.
Milwaukee Malleable & Grey Iron Works, 2773 S 29th St., Milwaukee 46, Wis.
Milwaukee Stamping Co., 800-S 72nd St., Milwaukee 14, Wis.
Milwaukee Valve Co., 2375 S. Burrell St., Milwaukee 7, Wis.
Mimosa Corp., 211 Covert Ave., Evansville, Ind.
Minimax Co., 5905 N Clark St., Chicago 26, Ill.
Minneapolis Electric Steel Casting Co., 3800 NE 5th St., Minneapolis 21, Minn.
Minneapolis Honeywell Regulator Co., 2753 4th Ave., S, Minneapolis 8, Minn.
Minnesota Mining & Mfg. Co., 900 Bush Ave., St. Paul 6, Minn.
Adhesives, Coatings & Sealers Div., 411 Piquette Ave., Detroit 2, Mich.
Irvington Varnish & Insulator Div., Irvington, N.J.
Mica Insulator Div., 797 Broadway, Schenectady 1, N.Y.
Reinforced Plastics Div., (Ad pp 206-207)
900 Fauquier Ave., St. Paul 6, Minn.
Zenith Plastics Co., Box 91, Gardena, Calif.
Minnesota Paints, Inc., 1101 S 3rd St., Minneapolis 15, Minn.
Minnesota Plastics Corp., 45 E Maryland Ave., St. Paul 3, Minn.
Minnesota Platon Corp., Hwy 23, Northeast Pipestone, Minn.
Minnesota Rubber Co., 3630 Wooddale Ave., Minneapolis 16, Minn.
Mirro Aluminum Co., 1512 Washington St., Manitowoc, Wis.
Misco Precision Casting Co., 116 W Gibbs, Whitehall, Mich.
Misner Corp., 940 N 23rd St., Omaha 2, Neb.
Missouri Boiler & Sheet Works, 23rd & Papin Sts., St. Louis 3, Mo.
Missouri Diecasting Co., 1411 N 17, St. Louis 6, Mo.
Missouri Rolling Mill Corp., 6800 Manchester Ave., St. Louis 10, Miss.
Missouri Steel Castings Co., 905 E 3rd St., Joplin, Mo.
Mitchell & Scott Machine Co., Inc., 1841 Ludlow Ave., Indianapolis 7, Ind.
Mitchell-Bradford Chemical Co., Wampus Lane, Milford, Conn.
Mobay Chemical Co., (Ad p 199)
1815 Washington Rd., Pittsburgh 34, Pa.
Mobile Paint Mfg. Co., Inc., 854 S Conception St., Mobile, Ala.
Moczik Tool & Die Works, 9511 Grinnell, Detroit 13, Mich.
Model Brass Co., Inc., 232-40 E Decatur St., Decatur, Ill.
Modern Brass Foundry & Mfg. Co., 157 Thurman St., Columbus 6, Ohio
Modern Plating Corp., 121-129 S Hancock Ave., Freeport, Ill.
Modern Screw Products Co., 2307 N 9th St., St. Louis 6, Mo.
Modiglass Fibers, Inc., Nicolet Ave., Florham Park, N.J.
Moldcast Products, Inc., Pacific St., Newark 5, N.J.
Molded Fiber Glass Co., (Ad p 364)
4401 Benefit Ave., Ashtabula, Ohio
Moldex, 747 5th Ave., New York 22, N.Y.
Moline Malleable Iron Co., St. Charles 5, Ill.
Monarch Aluminum Mfg. Co., (Ad p 336)
9205 Detroit Ave., Cleveland 2, Ohio
Monarch Products Co., Leake Stamping Div., 1259 E 1st St., Monroe, Mich.
Monarch Tool & Mfg. Co., 105 E 4th St., Covington, Ky.
Monroe Steel Castings Co., 917 W Front, Monroe, Mich.
Monsanto Chemical Co., 600 Monsanto Ave., Springfield, Mass.
Organic Chemicals Div., (Ad p 283)
Lindbergh & Olive St. Rd., St. Louis 24, Mo.
Plastics Div., Springfield 2, Mass.
Montague Machine Co., 15th St., Turners Falls, Mass.
Monteath, J.H. Co., 2504 Park Ave., New York, N.Y.
Moody Machine Products Co., Inc., 42 Dudley St., Providence 5, R.I.
Moore, George W., Inc., 100 Beaver St., Waltham 54, Mass.
Moore, Samuel & Co., Mantua, Ohio
Moore Dry Dock Co., Adeline St., Oakland 23, Calif.

Addresses of Suppliers

Morganite, Inc., 3302 48th Ave., Long Island City 1, N.Y.
Morningstar-Paisley, Inc., 630 W 51st St., New York 19, N.Y.
Morrell, George Corp., P.O. Box 155, Muskegon Heights, Mich.
Morrison Steel Products, Inc., 601 Amherst St., Buffalo 7, N.Y.
Morrisville Foundry Co., Inc., Morrisville, Vt.
Morse, Fred W. Co., 309 S Main St., Providence 3, R.I.
Mosinee Paper Mills Co., (Ad p 250)
Mosinee, Wis.
Mount Vernon Die Casting Corp., Southfield Ave., Stamford, Conn.
Mount Vernon Furnace & Mfg. Co., Mount Vernon, Ill.
Muehlstein, H. & Co., Inc., 60 E 42nd St., New York 17, N.Y.
Mueller Brasss Co., (Ad p 357)
1925 Lapeer Ave., Port Huron, Mich.
Mueller Machine Products, Inc., 3807 S Packard Ave., Milwaukee 7, Wis.
Multiple Extrusions, Inc., 1150-1200 E 8th St., Winona, Minn.
Muncie Malleable Foundry Co., E Highland Ave., Muncie, Ind.
Muncie Metal Spinning, Inc., 3000 S Hackley St., Muncie, Ind.
Mundt, Charles & Sons, 53 Fairmount Ave., Jersey City 4, N.J.
Murray, A.B. Co., Inc., P.O. Box 476, Elizabeth, N.J.
Murray Tube Works, Inc., P.O. Box 476, Elizabeth, N.J.
Muskegon Piston Ring Co., Sparta Foundry Div., Sparta, Mich.
Mycalex Corp. of America, 125 Clifton Blvd., Clifton, N.J.
Synthetic Mica Co. Div., 20 Passaic Ave., Caldwell, N.J.
Mystik Adhesive Products, Inc., 2635 N Kildare Ave., Chicago 39, Ill.

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Naige Co., Inc., 625 S Goodman St., Rochester 2, N.Y.
Napoleon Products Co., 410 Filmore St., Napoleon, Ohio
Narmco Resins & Coatings Co., 600 Victoria St., Costa Mesa, Calif.
Narragansett Boiler Works, Inc., 614 S Main St., Providence 3, R.I.
National Acme Co., 170 E 131st St., Cleveland 8, Ohio
National Aluminum Co., 1133 Alum Creek Dr., Columbus 9, Ohio
National Aluminum Co., Inc., 1912 Edgewood Ave., Racine, Wis.
National Aluminum & Brass Foundry, Inc., 1311 W Elm St., Independence, Mo.
National Aluminum Mfg. Co., 720 Park Ave., Peoria, Ill.
National Brass Works, Inc., 2140 E 25th St., Los Angeles 58, Calif.
National Casein Co., 601 W 80th St., Chicago 20, Ill.
National Copper & Smelting Co., 1862 E 123rd St., Cleveland 6, Ohio
National Distillers & Chemical Corp., U. S. Industrial Chemicals Co. Div., 99 Park Ave., New York 16, N.Y.
National Electric Products Corp., 2 Gateway Center, Pittsburgh 22, Pa.
National Felt Co., 76 Summer St., Boston 10, Mass.
National Forge & Ordnance Co., Irvine, Warren County, Pa.
National Galvanizing Co., Neville Island, Pittsburgh 25, Pa.
National Gasket & Washer Mfg. Co., Inc., 124 E 25th St., New York 10, N.Y.
National Grey Iron Foundry, Belvidere, Ill.
National Iron Co., 50th Ave. W & Famsey St., Duluth 7, Minn.
National Lead Co., 111 Broadway, New York 6, N.Y.
Doehler-Jarvis Corp., Toledo 1, Ohio
Titanium Alloy Mfg. Div., 2950 Hyde Park Blvd., Niagara Falls, N.Y.
Zirconium Metals Corp. of America Sub., 2950 Hyde Park Blvd., Niagara Falls, N.Y.
National Lead Construction Co., Inc., P.O. Box 133, Haddonfield, N.J.
National Lock Co., Fastener Div., 4500 Kishwaukee St., Rockford, Ill.
National Lock Washer Co., 40 Hermon St., Newark 5, N.J.
National Machine Products Co., 44225 Utica Rd., Utica, Mich.
National Malleable & Steel Castings Co., 10300 Quincy Ave., Cleveland 6, Ohio
National Mfg. Corp., 153 Fillmore Ave., Tonawanda, N.Y.
National Metal Products Co., 2 Gateway Center, Pittsburgh 22, Pa.
National Molded Products, Inc., 40 St. Marys St., St. Marys, Pa.
National Moldite Co., 250 South St., Newark 5, N.J.
National Paint & Manganese Co., Lynchburg, Va.
National Polymer Products, Inc., 125 N 4th St., Reading, Pa.
National Research Corp., 70 Memorial Dr., Cambridge 42, Mass.
National Screw & Mfg. Co., 2440 E 75th St., Cleveland 4, Ohio
National Starch Products, Inc., Structural Products Div., 750 3rd Ave., New York 17, N.Y.
National Steel Corp., Grant Bldg., Pittsburgh, Pa.
Enamelstrip Corp. Sub., 20th & Hamilton Sts., Allentown, Pa.
Great Lakes Steel Corp., Tecumseh Rd. at West Jefferson, Ecorse, Mich.
Weirton Steel Co., (Ad p 71)
Weirton, W. Va.
National Steel & Shipbuilding Corp., Harbor Dr. & 28th St., San Diego 12, Calif.
National Supply Co., 2 Gateway Center, Pittsburgh 22, Pa.
Industrial Products Div., P.O. Drawer 28, Torrance, Calif.
National Tank Co., Wells & Sandspring Rd., Tulsa, Okla.
National Telephone Supply Co., 5100 Superior Ave., Cleveland 3, Ohio
National Vulcanized Fibre Co., (Ad p 225)
Box 311, Wilmington 99, Del.
National-Standard Co., Howard & 8th Sts., Niles, Mich.
Athenia Steel Div., Clifton Ave., Clifton, N.J.
National Standard Div., 1939 Ward Rd., Niles, Mich.
Reynolds Wire Div., 809 E 2nd St., Dixon, Ill.
Worcester Wire Works Div., 70 James St., Worcester, Mass.
National-U. S. Radiator Corp., Plastic Metals Div., 4458A Bridge St., Johnstown, Pa.
Naugatuck Automatics, Inc., New Haven Rd., Naugatuck, Conn.
Neenah Foundry Co., Winneconne Ave., Neenah, Wis.
Neilson Chemical Co., 2300 Gainsboro, Ferndale 20, Mich.
Nesbitt Industries, Inc., 1823 Milwaukee Ave., Chicago 47, Ill.
Nesor Alloy Products Co., 282 Halsey St., Newark, N.J.
New Britain Machine Co., South St., New Britain, Conn.
New England Brass Co., 16 Parks Ave., Taunton, Mass.
New England Electrical Works, Inc., 365 Main St., Lisbon, N.H.
New England Laminates Co., Inc., (Ad p 220)
P.O. Box 43, 481 Canal St., Stamford, Conn.
New England Smelting Works, Inc., 502 Union St., West Springfield, Mass.
New England Tape Co., Inc., 40 Tower St., Hudson, Mass.
New Haven Copper Co., Main St., Seymour, Conn.
New Haven Screw Machine Products, Inc., 561 Boston Post Rd., Milford, Conn.
New Jersey Aluminum Extrusion Co., Inc., Jersey Ave., New Brunswick, N.J.
New Jersey Metals Co., 712 Rockefeller St., Elizabeth 2, N.J.
New Jersey Zinc Co., (Ad p 325)
160 Front St., New York 38, N.Y.
New Products Corp., 448 North Shore Ave., Benton Harbor, Mich.
New York Air Brake Co., Kinney Mfg. Div., 3529 Washington St., Boston 30, Mass.
New York Iron Roofing & Corrugating Co., Inc., 94 1st St., Jersey City 2, N. J.
Newage Industries, Inc., 222 York Rd., Jenkinstown 3, Pa.
Newark Wire Cloth Co., 351 Verona Ave., Newark 4, N.J.
Newman Bros., Inc., 670 W 4th St., Cincinnati, Ohio
Newman-Crosby Steel Co., Deane St., Pawtucket, R.I.
Newport Steel Corp., 9th & Thomas Sts., Newport, Ky.
Newth Rubber Co., County Rd., Barrington, R.I.
Newton-New Haven Co., 680 3rd Ave., West Haven, Conn.
Newtown Mfg. Co., Newtown, Conn.
Ney, J.M. Co., Industrial Div., P.O. Box 990, Hartford 1, Conn.
Nichols, L.O. & Son Mfg. Co., 1625 Locust St., Kansas City 8, Mo.
Nichols Wire & Aluminum Co., 1725 Rockingham Rd., Davenport, Iowa
Nicoud Mfg. Co., 3220 Grand Ave., Chicago 51, Ill.
Nigg Engineering Corp., 545 N 2nd Ave., Corina, Calif.
Nikoh Tube Co., 5000 S Whipple St., Chicago 32, Ill.
Nikolas, G.J. & Co., Inc., 2890 Washington Blvd., Bellwood, Ill.
Nilsen Mfg. Co., Electronicast Div., 21 N Church St., Addison, Ill.
Nixon Nitration Works, Nixon, N.J.
Noble & Wood Machine Co., 1st St., Hoosick Falls, N.Y.
Noera Mfg. Co., 236 Grand St., Waterbury 20, Conn.
Noland Tank & Galvanizing Co., 705 Merritt Ave., Nashville 4, Tenn.
Nolte Screw Machine Products Co., 1534-36 Freeman Ave., Cincinnati 14, Ohio
Nopco Chemical Co., 1st & Essex Sts., Harrison, N.J.
Norcross, C.S. & Sons Co., Dean & Davis Sts., Bushnell, Ill.
Norgren-Stemac, Inc., 5400 S Delaware, Littleton, Ohio
Norrich Plastics Corp., 107-109 W 18th St., New York, N.Y.
Screw Machine Products Div., 107-109 W 18th St., New York, N.Y.
North American Asbestos Corp., Board of Trade Bldg., Chicago 4, Ill.
North American Phillips Co., Inc., Elmet Div., Lewiston, Me.
North American Refractories Co., 1012 National City-E 6th Bldg., Cleveland 14, Ohio
North & Judd Mfg. Co., Wilcox-Crittenden Div., Middletown, Conn.
North Wales Foundry Co., Inc., Wessahickon Ave., North Wales, Pa.
Northern Malleable Iron Co., 867 Forest St., St. Paul 6, Minn.
Northern Plastics Corp., 2nd & Market St., La Crosse 9, Wis.
Northwest Automatic Products Corp., 1770 Linden Ave., Minneapolis 3, Minn.
Northwest Plastics Industries, Inc., 2040 15th Ave. W, Seattle 99, Wash.
Northwestern Machine Corp., 3014 Hadley St., St. Louis 7, Mo.
Northwestern Steel & Wire Co., Ave. B & Wallace St., Sterling, Ill.
Norton Co., (Ad p 288)
New Bond St., Worcester 6, Mass.
Norwalk Powdered Metals, Inc., P.O. Box 271, Muller Park, Norwalk, Conn.
Norwich Leather Co., 685 N Main St., Norwich, Conn.
Nukem Products Corp., 111 Colgate Ave., Buffalo 20, N.Y.
Nu-Ply Corp., Bemidji, Minn.
Nutmeg Crucible Steel Co., Elm & Harbor Sts., Branford, Conn.
Nutmeg Screw Machine Products Co., Wolcott Rd., Wolcott, Conn.
Nutt-Shel Co., 811 Airway, Glendale 1, Calif.

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Oak Hill Foundry & Machine Works, Box 278, Oak Hill, Ohio
Oakes Bronze & Aluminum Co., Bronze Rd., Warren, Ohio
Oakite Products, Inc., 19 Rector St., New York 6, N.Y.
Oakland Foundry & Machine Co., 607-621 Woodward Ave., Rochester, Mich.
Oatey, L.R. Co., 10230 Berea Rd., Cleveland 2, Ohio
Octagon Process, Inc., 63 Bank St., Staten Island 1, N.Y.
Ohio Adhesives Corp., P.O. Box 466, New Philadelphia, Ohio
Ohio Carbon Co., (Ad p 340)
12508 Berea Rd., Cleveland 11, Ohio
Ohio Forge & Machine Corp., 3010 Woodhill Rd., Cleveland 4, Ohio
Ohio Metal Products Co., 35 N Bates St., Dayton 2, Ohio
Ohio Nut & Bolt Co., 33 1st Ave., Berea, Ohio
Ohio Nut & Washer Co., Box 66, Mingo Junction, Ohio
Ohio Precision Castings, Inc., 109 Webb St., Dayton 3, Ohio
Ohio Rubber Co., 301 Ben Hur Ave., Willoughby, Ohio
Ohio Screw Products, Inc., 818 West St., Elyria, Ohio
Ohio Steel Foundry Co., 1075 James St., Springfield, Ohio
Oil City Iron Works, S 12th St. & SPRR, Corsicana, Tex.
Olderman Mfg. Corp., P.O. Box 917, Bridgeport, Conn.
Olds Alloys Co., 4481 Mason St., South Gate, Calif.
Olean Electro Plating Co., 890 N 5th St., Olean, N.Y.
Olin Mathieson Chemical Corp., 460 Park Ave., New York 22, N.Y.
Aluminum Div., 460 Park Ave., New York 22, N.Y.
Film Div., 655 Madison Ave., New York 21, N.Y.
Olson Mfg. Co., 100 Prescott St., Worcester 5, Mass.
Olympic Steel Works, 151 Horton St., Seattle 4, Wash.
Omaha Steel Works, 609 S 48th St., Omaha 6, Neb.
Omni Products Corp., 460 4th Ave., New York 16, N.Y.
Omni-Metal Castings, Inc., 135 11th St., Brooklyn 15, N.Y.
Orange Roller Bearing Co., Inc., 555 Main St., Orange, N.J.

Oregon Brass Works, 1127 SE 10th Ave., Portland 14, Ore.
Oregon Metallurgical Corp., P.O. Box 484, Albany, Ore.
Ormand Mfg. Co., Inc., 3325 Hudson Ave., Union City, N.J.
Ostby & Barton Co., Flightex Fabrics, Inc., 148 W River St., Providence 4, R.I.
O'Sullivan Rubber Corp., Valley Pike St., Winchester, Va.
Ottawa Steel Products, Inc., 745 Woodlawn Ave., Grand Haven, Mich.
Overmyer Mould Co., Inc., N Main St., Winchester, Ind.
Owen Mfg., Inc., S State Street Rd., Litchfield, Ill.
Owen Pattern Foundry & Mfg. Co., Inc., 710 W 22nd St., Norfolk 10, Va.
Owens-Corning Fiberglas Corp., 608 Madison Ave., Toledo 3, Ohio
Owens-Illinois Glass Co., Toledo, Ohio

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Pabst Engineering Equipment Co., Inc., 676 Pennsylvania Ave., Elizabeth 3, N.J.
Pacific Brass Foundry of San Francisco, 251 2nd St., San Francisco 5, Calif.
Pacific Coast Foil Co., 500 Sansome St., San Francisco, Calif.
Pacific Foundry Co., Ltd., 3100 19th St., San Francisco, Calif.
Pacific Screw Products Co., 930 Linden Ave., South San Francisco, Calif.
Pacific Sintered Metals Co., 7728 El Manor Ave., Los Angeles, Calif.
Pacific States Steel Corp., Niles, Calif.
Pacific Tube Co., 5710 Smithway St., Los Angeles 22, Calif.
Page Belting Co., Concord, N.H.
Palmyra Foundry Co., Inc., Palmyra, N.J.
Palnut Co., Glen Rd., Mountainside, N.J.
Pan-American Metal Products Co., Inc., 401 NW 71st St., Miami 38, Fla.
Panther Chemical Corp., P.O. Box 711, Ft. Worth, Texas
Paragon Die Casting Co., 5851 W Dickens Ave., Chicago 39, Ill.
Paragon Spring Co., 4613-17 W Fulton St., Chicago 44, Ill.
Paramount Die Casting Co., St. Joseph, Mich.
Paramount Paint & Lacquer Co., 3411 E 15th St., Los Angeles 23, Calif.
Park Drop Forge Co., 777 E 79th St., Cleveland 3, Ohio
Parker, Charles Co., Hanover St., Meriden, Conn.
Parker Appliance Co., Rubber Products Div., 17325 Euclid Ave., Cleveland 12, Ohio
Parker & Harper Mfg. Co., 119 Dewey St., Worcester 10, Mass.
Parker Metal Goods Co., 85 Prescott St., Worcester, Mass.
Parker Paint Mfg. Corp., Locust & Poplar Sts., Valparaiso, Ind.
Parker Rust Proof Co., 2177 E Milwaukee, Detroit 11, Mich.
Parker, Stearns & Co., Inc., 300 Sheffield Ave., Brooklyn 7, N.Y
Parker White Metal Co., (Ad p 333)
2153 McKinley Ave., Erie, Pa.
Parker-Hannifin Corp., Parker Seal Div., 17325 Euclid Ave., Cleveland 12, Ohio
Parker-Street Castings Co., Broadway & Chaincraft Rd., Cleveland 25, Ohio
Parkwood Laminates, Inc., 24 Water St., Wakefield, Mass.
Patterson Foundry & Machine Co., 41 Henene St., East Liverpool, Ohio
Pattin Mfg. Co., Box 527, Marietta, Ohio
Paulson, Thomas & Son, Inc., 450 Union St., Brooklyn 31, N.Y
Pawling Rubber Corp., Pawling, N.Y.
Payne, F.S. Co., 75 Richdale Ave., Cambridge 40, Mass.
Peasley Products, Inc., 993 Honeyspot Rd., Stratford, Conn.
Peck Spring Co., Whiting St., Plainville, Conn.
Pecora Inc., 300-400 W Sedgley Ave., Philadelphia 40, Pa.
Peerless Alloy Co., 1445 Osage St., Denver 4, Colo.
Peerless Automatic Machine Co., 1970 W 77th St., Cleveland 2, Ohio
Peerless Industries, Inc., P.O. Box 318, Plymouth, Mich.
Peerless Products Industries, 812-14-16 N Pulaski Rd., Chicago 51, Ill.
Peerless Roll Leaf Co., Inc., 4511 New York Ave., Union City, N.J.
Pelron Corp., 7847 W 47th St., Lyons, Ill.
Pelton Steel Casting Co., 148 W Dewey Pl., Milwaukee 7, Wis.
Pemco Corp., Eastern & Pemco Aves., Baltimore, Md.
Pemco Wheel Co., 1872 Ravine Rd., Kalamazoo, Mich.
Penberthy Instrument Co., 4301 6th Ave. S, Seattle 8, Wash.
Pencoyd Steel & Forge Corp., 3720-40 Main St., Philadelphia 27, Pa.
Peninsular Steel Co., P.O. Box 3853, Parkgrove Sta., Detroit 5, Mich.
Penn Brass & Copper Co., 3837 W 20th St., Erie, Pa.
Penn Extrusion Corp., 3837 W 20th St., Erie, Pa.
Penn Fibre & Specialty Co., Inc., 2024 E Westmoreland St., Philadelphia 34, Pa.
Penn Metal Co., Inc., P.O. Box 1480, Parkersburg, W. Va.
Penn Metal Co., Inc., 40 Central St., Boston 9, Mass.
Penn Precision Products, Inc., 501 Crescent Ave., Reading, Pa.
Penn Steel Castings Co., Front & Penn Sts., Chester, Pa.
Pennsalt Chemicals Corp., 3 Penn Center, Philadelphia 2, Pa.
Pennsylvania Engineering Corp., P.O. Box 311, New Castle 17, Pa.
Pennsylvania Malleable Iron Corp., 712 S Prince St., Lancaster, Pa.
Pennsylvania Range Boiler Co., 24th & Ellsworth Sts., Philadelphia 46, Pa.
Penrod, Floyd & Sons Tool & Engineering Corp., 1208 W 2nd St., Muncie, Ind.
Peoria Malleable Casting Co., 2800 N Adams St., Peoria 1, Ill.
Peoria Plastic Co., East Peoria, Ill.
Pequonnock Foundry, Inc., 335 5th St., Bridgeport, Conn.
Perfecto Cast, 5660 Kearney Villa Rd., San Diego 11, Calif.
Perfex Plastics, Inc., 2632 S Dearborn, Chicago 16, Ill.
Perkins, Henry Co., Broad St., Bridgewater, Mass.
Permacel-LePage's, Inc., U. S. Hwy. #1, New Brunswick, N.J.
Permold Co., 1250 W Liberty St., Medina, Ohio
Perrin, Edward C. Co., 3rd & Grant Sts., Camden 2, N.J.
Perry Fay Co., 200 Perry Court, Elyria, Ohio
Perry Plastics, Inc., 3409 W 14th St., Erie, Pa.
Perry-Austen Mfg. Co., 250 Parkinson Ave., Staten Island 5, N.Y.
Peterson Products Corp., 4848 N River Rd., Schiller Park, Ill.
Pettibone Mulliken Corp., 4700 W Division St., Chicago 51, Ill.
Pfaudler Co., West Ave. & Clark St., Rochester 3, N.Y.
Pfister Aluminum Corp., 475 Franklin Tpke., Allendale, N.J.
Phelps Dodge Copper Products Corp., 2010 N 10th St., Philadelphia 22, Pa.
Phelps Dodge Refining Corp., 40 Wall St., New York, N.Y.
Pheoll Mfg. Co., 5700 W Roosevelt Rd., Chicago 50, Ill.
Philadelphia Asbestos Corp., 2010 N 10th St., Philadelphia 22, Pa.
Philadelphia Enameling Works, Inc., 254 N 13th St., Philadelphia 7, Pa.
Philadelphia Steel & Wire Corp., Penn St. & Belfield Ave., Philadelphia 44, Pa.
Philco Corp., Dexter Foundry Div., 501 N 8th St., Fairfield, Iowa
Phillips, F.C. Inc., 471 Washington St., Stoughton, Mass.
Phillips Chemical Co., Plastics Sales Div., (Ad pp 221-24)
Adams Bldg., Bartlesville, Okla.
Philrus Products Co., 135 Newark St., Newark 4, N.J.
Phoenix Die Casting Co., 21-23 Illinois St., Buffalo 3, N.Y.
Phoenix Iron & Steel Co., Front & Dock Sts., Harrisburg, Pa.
Phoenix Products Co., 4715 N 27th St., Milwaukee 9, Wis.
Picco, Inc., 1729 N Chico Ave., El Monte, Calif.
Pierce, F.O. Co., 2-33 50th Ave., Long Island City 1, N.Y.
Pierce Governor of Ohio, Inc., Asbestos Ave., Alliance, Ohio
Pierce & Stevens Chemical Corp., 710 Ohio St., Buffalo, N.Y.
Pilgrim Plywood Corp., Waterbury, Vt.
Pioneer Aluminum Inc., 5251 W Imperial Blvd., Los Angeles 45, Calif.
Pioneer Stamped Products Co., P.O. Box 185, Roselawn Sta., Rochester 18, N.Y.
Piper Tool Co., Inc., 15930 Common Rd., Roseville, Mich.
Pittsburgh Corning Corp., 1 Gateway Center, Pittsburgh 22, Pa.
Pittsburgh Die & Casting Co., 7503 Ardmore St., Pittsburgh 18, Pa.
Pittsburgh Forgings Co., 919 Amur St., Jackson, Mich.
Pittsburgh Forgings Co., Thorn St., Coraopolis, Pa.
Pittsburgh Foundry & Machine Co., 36th St., Pittsburgh 1, Pa.
Pittsburgh Plate Glass Co., 632 Ft. Duquesne Blvd., Pittsburgh 22, Pa.
Fiber Glass Div., (Ad p 209)
1 Gateway Center, Pittsburgh 22, Pa.
Forbes Finishes Div., 3800 W 143rd St., Cleveland, Ohio
Pittsburgh Smelting & Refining Co., 100 W Elizabeth St., Pittsburgh 7, Pa.
Pittsburgh Steel Co., P.O. Box 118, Pittsburgh 19, Pa.
Thomas Strip Div., (Ad pp 74-5)
Grant Bldg., Pittsburgh 30, Pa.
Pittsburgh Steel Foundry Corp., P.O. Box 986, Pittsburgh 30, Pa.
Fort Pitt Steel Casting Div., 25th St., McKeesport, Pa.
Pittsburgh Tool Steel Wire Co., Monaca, Pa.
Pittsburgh Tube Co., 212 Wood St., Pittsburgh 22, Pa.
Plast-Ad Mfg. Co., 222 N Michigan St., South Bend 1, Ind.
Plastex Co., 3232 Cleveland Ave., Columbus 24, Ohio
Plastic Engineering, Inc., (Ad p 202)
8506 Lake Ave., Cleveland 2, Ohio
Plastic Masters, Inc., New Buffalo, Mich.
Plastic Materials, Inc., New South Rd., Hicksville, N.Y.
Plastic Packaging Co., 2025 W Charleston St., Chicago 47, Ill.
Plastic Pipe & Tube Corp., 224 S Mipas St., Santa Barbara, Calif.
Plastic Process Co., Inc., 10400 Aviation Blvd., Los Angeles 45, Calif.
Plasticrafters, Inc., 1829 S 55th Ave., Cicero 50, Ill.
Plastics Engineering Co., 1607 Geele Ave., Sheboygan, Wis.
Plastiglide Mfg. Corp., 1757 Stanford St., Santa Monica, Calif.
Carroll Plastic Compounding Corp., 3122 Nebraska Ave., Santa Monica, Calif.
Pipco International Corp., 1731 Stanford St., Santa Monica, Calif.
Plax Corp., Box 1019, Hartford, Conn.
Plumb Chemical Corp., 4837 James St., Philadelphia 37, Pa.
Plymouth Industrial Products, Inc., 502 Indiana Ave., Sheboygan, Wis.
Pohlman, R.L. Co., 6730 Olive St. Rd., St. Louis 5, Mo.
Pohlman Foundry Co., Inc., 205 Baitz Ave., Buffalo 6, N.Y.
Polacoat, Inc., 9752 Conklin Rd., Cincinnati 42, Ohio
Pollock, Robert Co., 123 S Maryland Ave., Glendale, Calif.
Polo Plastics Co., 1718 N 1st St., Milwaukee 12, Wis.
Poly Resins, 11661 Wicks St., Sun Valley, Calif.
Polyform Plastics Corp., 24 University Pl., New York 3, N.Y.
Polygon Plastic Co., Walkerton, Ind.
Polymer Chemical Co., 5920 Carthage Ave., Cincinnati 12, Ohio
Polymer Corp. of Pennsylvania, 2140 Fairmont Ave., Reading, Pa.
Polyphase Machine Co., 43-22 50th St., Woodside 77, N.Y.
Polyplastic Products, Inc., 24th Ave., Paterson, N.J.
Poor & Co., 80 E Jackson Blvd., Chicago, Ill.
Canton Forge & Axle Works, 2025 Dueber Ave., SW, Canton 6, Ohio
Promat Div., 851 S Market St., Waukegan, Ill.
Porcelain Enamel Finishers, 3221 W 30th St., Chicago 23, Ill.
Porcelain Products, Inc., 224 N Patterson, Carey, Ohio
Portable Electric Tools, Inc., Admiral Die Castings Div., 250 W 83rd St., Chicago 20, Ill.
Porter, H.K. Inc., 74 Foley, Somerville 43, Mass.
Porter, H.K. Co., Inc., Alcoa Bldg., Pittsburgh 19, Pa.
Connors Steel Div., 5000 Powell Ave,. Birmingham 6, Ala.
Forge & Fittings Div., 3270 E 79th St., Cleveland 4, Ohio
Quaker Rubber Div., Tacony & Comly Sts., Philadelphia 24, Pa.
Refractories Div., 250 1st National Bank Bldg., Pittsburgh 22, Pa.
Riverside-Alloy Metal Div., 1 Pavillion Ave., Riverside, N.J.
Vulcan-Kidd Steel Div., Aliquippa, Pa.
Porter, William Co., 1007 Santa Fe Ave., Los Angeles 21, Calif.
Portland Co., 58 Fore St., Portland, Me.
Portland Iron Works, 1335 NW Northrup St., Portland 9, Ore.
Posey Iron Works, Inc., 580 S Prince St., Lancaster, Pa.
Potts, C. & G. & Co., 816 Washington Ave., Indianapolis, Ind.
Powder Metals Products Co., 500 St. Marys St., St. Marys, Pa.
Powdercraft Corp., 746 Hayne St., Spartanburg, S. C.

Addresses of Suppliers

Powell Pressed Steel Co., Hubbard, Ohio
Pratt & Lambert, Inc., 75 Tonawanda St., Buffalo 7, N.Y.
Pratt, William E. Mfg. Co., 155 N Wacker Dr., Chicago, Ill.
Precision Castparts Corp., 4600 SE Harney Dr., Portland 6, Ore.
Precision Extrusions, Inc., 132 S Addison St., Bensenville, Ill.
Precision Founders, Inc., 414 Hester St., San Leandro, Calif.
Precision Machine Co., 1110 E 22nd St., Indianapolis 2, Ind.
Precision Metal Products Co., P.O. Box 129, Ellwood City, Pa.
Precision Metal Spinning Co., 9861 Dixie Hwy., Clarkston, Mich.
Precision Metalsmiths, Inc., 1081 E 200 St., Cleveland 17, Ohio
Precision Paper Tube Co., 2035 W Charleston St., Chicago 47, Ill.
Precision Piece Parts, Inc., 712 S Logan St., Mishawaka, Ind.
Precision Rubber Products Corp., 3110 Oakridge Dr., Dayton 7, Ohio
Precision Screw Products Co., Inc., 4764 Valley Blvd., Los Angeles 32, Calif.
Precision Tube Co., Inc., Church Rd. & Wissahickon Ave., North Wales, Pa.
Premier Metal Works, Inc., 1616 S Clinton St., Chicago 16, Ill.
Premier Thermo Plastics Co., Jeffersontown, Ky.
Prescott Co., 1610 15th St., Menominee, Mich.
Presmet Corp., 112 Harding St., Worcester 4, Mass.
Pressed Steel Co., Wilkes Barre, Pa.
Pressed Steel Tank Co., 1493 S 66th St., Milwaukee 14, Wis.
Presstite-Keystone Engineering Products Co., (Ad p 208)
3738 Chouteau Ave., St. Louis, Mo.
Presswork, Inc., 9100 Rose Lawn St., Detroit 4, Mich.
Presto Plastic Products Co., Inc., 11 E 26th St., New York 10, N.Y.
Prima Pipe Co., 1108 Pulliam, San Angelo, Texas
Prince Rubber Co., Inc., 1675 Niagara St., Buffalo 7, N.Y.
Progressive Service Co., 2745 Locust St., St. Louis 3, Mo.
Protective Treatments, Inc., 420 Dellrose Ave., Dayton, Ohio
Puget Sound Plywood, Inc., 230 E. F St., Tacoma 2, Wash.
Pure Carbon Co., Inc., 441 Hall Ave., St. Marks, Pa.
Puritan Co., Inc., Beach & Lyell Aves., Rochester, N.Y.
Pusey & Jones Corp., Front & Poplar Sts., Wilmington 9, Del.
Pyramid Industries, Inc., 1422 Irwin Dr., Erie, Pa.
Pyramid Mouldings, Inc., 5353 W Armstrong Ave., Chicago 46, Ill.
Pyramid Plastics, Inc., 554 W Polk St., Chicago 7, Ill.
Pyro Plastics Corp., Pyro Park, Union, N.J.
Pyron Corp. (Ad p 338)
Box E, LaSalle Sta., Niagara Falls, N.Y.
Pyrosil, Inc., P.O. Box 206, Cuyahoga Falls, Ohio

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Quaker Alloy Casting Co., Myerstown, Pa.
Quaker City Felt Co., 1734-36 Ludlow St., Philadelphia, Pa.
Quaker State Metals Co., P.O. Box 1167, Lancaster, Pa.
Quality Electric Steel Castings, Inc., P.O. Box 9382, Houston 11, Tex.
Queen Products Co., Inc., 13th & Rowan Sts., Louisville 3, Ky.
Albert Lea Foundry Div., 902-910 Marshall, Albert Lea, Minn.
Quelcor, Inc., Front & Broomall Sts., Chester, Pa.
Quest, J.F. Foundry Co., 900 4th St., S, Minneapolis 15, Minn.
Quincy Steel Casting Co., 30 Fayette St., North Quincy 71, Mass.

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Racine Screw Co., 1501 Clark St., Racine, Wis.
Radiant Color Co., 830 Isabella St., Oakland 7, Calif.
Raffi and Swanson, Inc., 100 Eames St., Wilmington, Mass.
Rainier Metal Products Co., 2412 W 71st St., Chicago 29, Ill.
Rand Rubber Co., 397 Sumner Ave., Brooklyn 16, N.Y.
Randolph Products Co., 18 12th St., Carlstadt, N.J.
Rangers Die Casting Co., 10828 S Alameda St., Lynwood, Calif.
Rankin Forge Co., 117 Fort Pitt Blvd., Pittsburgh 22, Pa.
Rasco-Veeder Co., 1600 S Dearborn St., Chicago 16, Ill.
Rathbone Corp., Park St., Palmer, Mass.
Rausch Mfg. Co., 750 Pelham Blvd., St. Paul 14, Minn.
Ravenswood Machine Corp., 3325 N Knox Ave., Chicago 41, Ill.
Raybestos-Manhattan, Inc., 61 Willett St., Passaic, N.J.
Adhesives Div., P.O. Box 1021, Bridgeport 2, Conn.
Plastic Products Div., P.O. Box 1021, Bridgeport 2, Conn.
Raybestos Div., P.O. Box 1021, Bridgeport 2, Conn.
Reade Mfg. Co., Inc., 135 Hoboken Ave., Jersey City 2, N.J.
Reading Tube Corp., Empire State Bldg., 350 5th Ave., New York, N.Y.
Red Devil Mfg. Co., 1412 N Ogden Ave., Chicago 10, Ill.
Redmer Air Devices, Box 247, Guntersville, Ala.
Reed Plastics Corp., 116 Gold St., Worcester 8, Mass.
Reed & Prince Mfg. Co., 1 Duncan Ave., Worcester 1, Mass.
Rees', Hans Sons, 39 Frankfort St., New York 38, N.Y.
Reese Metal Products Corp., 537 Howard Ave., Lancaster, Pa.
Reeves Bros., Inc., Vulcan Rubber Products Div., 1071 Ave. of Americas, New York, N.Y.
Refinery Castings Co., P.O. Box 5085, Dallas 22, Tex.
Reflin Co., 5730 Kearney Villa Rd., San Diego 11, Calif.
Refractory & Insulation Corp., 120 Wall St., New York 5, N.Y.
Refractory Specialties Co., 2200 Washington Ave., Philadelphia 46, Pa.
Regal Plastic Co., 2800 E 14th St., Kansas City 27, Mo.
Regal Ware, Inc., Kewashum, Wis.
Reichhold Chemicals, Inc., 525 N Broadway, White Plains, N.Y.
Reilly Tar & Chemical Corp., 1615 Merchant Bank Bldg., Indianapolis 4, Ind.
Reinhold Engineering & Plastics Co., 12827 E Imperial Hwy., Norwalk, Calif.
Reliable Screw Machine Products, 4433 W Rice St., Chicago 51, Ill.
Reliable Spring & Wire Forms Co., 3167 Fulton Rd., Cleveland 9, Ohio
Reliance Foundry Co., 500-526 E Front St., Cincinnati 2, Ohio
Reliance Plastic & Chemical Corp., 110 Kearney St., Paterson 2, N.J.
Reliance Steel Castings Co., 2818 Smallman St., Pittsburgh 22, Pa.
Remler Co., Ltd., 2101 Bryant St., San Francisco 10, Calif.
Ren Plastics, Inc., 5422 S Cedar Rd., Lansing 17, Mich.
Rensselaer Valve Co., Cohoes, N.Y.
Replac Corp., 2130 St. Clair Ave., Cleveland 17, Ohio
Republic Die Casting Co., 611 Talcott Ave. St. Louis 7, Mo.
Republic Lead Equipment Co., 7930 Jones Rd., Cleveland 5, Ohio
Republic Metals Co., Inc., 273 Green, Brooklyn 22, N.Y.
Republic Steel Corp., (Ad pp 78-9)
Republic Bldg., Cleveland 1, Ohio
Steel & Tubes Div., 224 E 131st St., Cleveland 8, Ohio
Resin Industries, Olive St., Santa Barbara, Calif.
Resistoflex Corp., Woodland Rd., Roseland, N.J.
Resolite Corp., P.O. Box 366, Zelienople, Pa.
Revere Copper & Brass, Inc., 230 Park Ave., New York 17, N.Y.
Foil Div., 196 Diamond St., Brooklyn 22, N.Y.
Rome Mfg. Div., Mill St., Rome, N.Y.
Rex Corp., Hayward Rd., West Acton, Mass.
Rex Products Co., 1918 E 55th St., Cleveland 3, Ohio
Reynolds Aluminum Supply Co., 573 W Peachtree St., NE, Atlanta 3, Ga.
Reynolds Chemical Products Co., (Ad p 216)
1200 N Main St., Ann Arbor, Mich.
Reynolds Mfg. Co., Springfield, Mass.
Reynolds Metal Co., 2500 S 3rd St., Louisville, Ky.
Reynolds Metals Co., P.O. Box 2346-2H, Richmond 18, Va.
Rezolin, Inc., 1051 18th St., Santa Monica, Calif.
Rhoads, J.E. & Sons, 2100 W 11th St., Wilmington, Del.
Rhode Island Tool Co., (Ad p 342)
142 W River St., Providence 1, R.I.
Richardson Co., 2882 Lake St., Melrose Park, Ill.
Richmond Foundry & Mfg. Co., Inc., 1300 Hermitage Rd., Richmond 20, Va.
Richmond Mfg. Co., 312 N York St., Houston 4, Tex.
Richmond Mica Corp., 900 Jefferson Ave., Newport News, Va.
Ridge Foundry, 1554 Doolittle Dr., San Leandro, Calif.
Riegel Paper Co., 260 Madison Ave., New York 16, N.Y.
Rigidized Metals Corp., 658 Ohio St., Buffalo 3, N.Y.
Rinshed-Mason Co., Milford at Epworth, Detroit, Mich.
River Smelting & Refining Co., 4195 Bradley Rd., Cleveland 1, Ohio
Riverside Foundry Co., N Front St., Wrightsville, Pa.
Riverside Foundry & Galvanizing Co., 508 Harrison St., Kalamazoo, Mich.
Riverside Plastics Corp., 220 Miller Rd., Hicksville, N.Y.
Robertson, H.H. Co., 2400 Farmer Bank Bldg., Pittsburgh, Pa.
Robertson Steel & Iron Co., 72 Elm St., Cincinnati 2, Ohio
Robot Devices, Inc., Main St., Buchanan, Va.
Rochester Novelty Works, Inc., 485 Hague St., Rochester 6, N.Y.
Rockford Bolt & Steel Co., 125 Mill St., Rockford, Ill.
Rockwell Mfg. Co., Lem Mfg. Co., Inc. Sub., Atchison, Kan.
Rockwell Spring and Axle Co., Bossert Div., 1002 Oswego St., Utica 1, N.Y.
Rockwell-Standard Corp., Stamping Div., (Ad p 348)
1002 Oswego St., Utica 1, N.Y.
Roddis Plywood Corp., Marshfield, Wis.
Rode, Inc., R5 Green St., Woburn, Mass.
Rodney Hunt Machine Co., 46 Mill St., Orange, Mass.
Rodney Metals, Inc., 261 5th Ave., New York 16, N.Y.
Roebling's, John A. Sons Corp., 640 S Broad St., Trenton 2, N.J.
Rogers Corp., Rogers, Conn.
Rogers, V.F. Plastic Molding, 4320 Fox St., Denver 16, Colo.
Rohm & Haas Co., (Ad p 201)
Washington Square, Philadelphia 5, Pa.
Rolinco, Inc., 116 Limestone, Bellevue, Peoria 5, Ill.
Roll Coater, Inc., Box 67, Pendleton, Ind.
Roll Formed Products Co., (Ad p 337)
3752 Oakwood Ave., Youngstown, Ohio
Rolle Mfg. Corp., 3rd & Cannon St., Lansdale, Pa.
Rolled Alloys, Inc., 4815 Bellevue Ave., Detroit, Mich.
Rolock, Inc., 1350 Kings Hwy., Fairfield, Conn.
Romar Plastics, Inc., 1311 E Main St., St. Charles, Ill.
Rome Strip Steel Co., Inc., 530 Henry St., Rome, N.Y.
Rome Turney Radiator Co., Rome, N.Y.
Rosan, Inc., 2901 W Coast Hwy., Newport Beach, Calif.
Rosco Laboratories, 29 Moore St., Brooklyn 6, N.Y.
Rose Iron Works, 1539 E 43rd St., Cleveland 3, Ohio
Rosedale Foundry & Machine Co., 1731 Prebel Ave., Pittsburgh 33, Pa.
Ross & Roberts, Inc., 1299 W Broad St., Stratford, Conn.
Ross-Meehan Foundries, 1601 Carter St., Chattanooga 1, Tenn.
Rostone Corp., Rd. 52 S, Lafayette, Ind.
Roth Rubber Co., 1854 S 54th St., Chicago 50, Ill.
Roth Steel Products Co., 1335 E 171st St., Cleveland 10, Ohio
Rotometals, 980 Harrison St., San Francisco 7, Calif.
Rotor Clip Co., 114 Allen Blvd., Farmingdale, N.Y.
Rowland Products, Inc., Fairview Lane, Kensington, Conn.
Royce Aluminum Corp., 704 W Water St., Taunton, Mass.
Rubber & Asbestos Corp., 225 Belleville Ave., Bloomfield, N.J.
Rubber Corp. of America, New South Rd., Hicksville, L.I., N.Y.
Rubber & Plastics Compound Co., Inc., 10 Rockefeller Plaza, New York 20, N.Y.
Ruberoid Co., 500 5th Ave., New York 36, N.Y.
Ruby Chemical Co., 68-70 McDowell St., Columbus 16, Ohio

In contacting suppliers, please mention the Materials Selector

Rupert Diecasting Co., 1655 Cleveland Ave., Kansas City 27, Mo.
Russell, Burdsall & Ward Bolt & Nut Co., Midland Ave., Port Chester, N.Y.
Russell Mfg. Co., 400 E Main St., Middletown, Conn.
Russell Reinforced Plastics Corp., 521 W Hoffman Ave., Lindenhurst, N.Y.
Rust-Oleum Corp., 2425 Oakton St., Evanstown, Ill.
Rustproofing & Metal Finishing Corp., 75 Commercial Ave., Cambridge 42, Mass.
Ryerson, Joseph T. & Son, Inc., 16th & Rockwell Sts., Chicago 80, Ill.

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S & S Mfg. Co., 6139 Adams St., West New York, N.J.
Saginaw Bearing Co., 821 S Water St., Saginaw, Mich.
St. Joseph Lead Co., 250 Park Ave., New York 17, N.Y.
St. Louis Diecasting Corp., 4528 Oleatha Ave., St. Louis 16, Mo.
St. Louis Malleable Casting Co., 7701 N Conduit Ave., St. Louis, Mo.
St. Louis Steel Casting, Inc., 100 Mott St., St. Louis 15, Mo.
St. Marys Carbon Co., State Rd., St. Marys, Pa.
St. Marys Foundry Co., P.O. Box 248, St. Marys, Ohio
St. Pierre Chain Corp., 50 Frank St., Worcester 4, Mass.
St. Regis Paper Co., 150 E 42nd St., New York, N.Y.
Chester Packaging Div., 684 Nepperhan Ave., Yonkers, N.Y.
Panelyte Div., 261 Madison Ave., New York 16, N.Y.
Salem Tool Co., 767 S Ellsworth Ave., Salem, Ohio
Sall Bros. Co., 2300 Kishwaukee St., Rockford, Ill.
Sall, George Metals Co., Inc., 2255 E Butler St., Philadelphia 37, Pa.
San Francisco Galvanizing Works, 1180 Harrison St., San Francisco 3, Calif.
San Francisco Iron Foundry, 260 Townsend St., San Francisco 7, Calif.
Sandusky Foundry & Machine Co., (Ad p 345)
W Market St., Sandusky, Ohio
Sandvik Steel, Inc., (Ad p 68)
1702 Nevins Rd., Fair Lawn, N.J.
Sandy Hill Iron & Brass Works, 27 Allen St., Hudson Falls, N.Y.
Sanford Plastics Corp., 521 Fifth Ave., New York 17, N.Y.
Saramar Aluminum Co., 4021 Mahoning Ave., Youngstown 1, Ohio
Saran Lined Pipe Co., 2415 Burdette Ave., Ferndale 20, Mich.
Sargent & Greenleaf, Inc., 24 Seneca Ave., Rochester 21, N.Y.
Sauereisen Cements Co., 1045 N Canal St., Pittsburgh 15, Pa.
Sawbrook Steel Castings Co., Shepherd & McWhorter Sts., Lockland, Cincinnati 15, Ohio
Sawhill Tubular Products, Inc., P.O. Box 546, Sharon, Pa.
Saxonburg Ceramics, Saxonburg, Pa.
Scaife Co., Anne St., Oakmont, Pa.
Schachner Leather & Belting Co., 1123 S Mint St., Charlotte 1, N.C.
Schaefer-Goodnow Foundries, Inc., 2 36th St., Philadelphia 1, Pa.
Schenectady Varnish Co., Inc., Congress St. & 9th Ave., Schenectady 3, N.Y.
Schilling Bronze Co., 202-216 E North St., Rome 2, N.Y.
Schlueter Mfg. Co., 4616 N Broadway, St. Louis 7, Mo.
Schmeller Aluminum Foundry Co., 3300 E 87th St., Cleveland 27, Ohio
Schneider, Bowman Co., Inc., 1612 Van Dyke St., Philadelphia 24, Pa.
Schultz Die Casting Co., 1810 Clinton St., Toledo 7, Ohio
Schumann, I. & Co., 4391 Bradley Rd., P.O. Box 2219, Cleveland 9, Ohio
Schwab Plastics Corp., 730 S Dix St., Detroit 7, Mich.
Schwartz Chemical Co., Inc., 50-01 2nd St., Long Island City, N.Y.
Schwarzkopf Development Corp., 595 Madison Ave., New York 22, N.Y.
Scottdale Ozone Co., Crescent St., Scottdale, Pa.
Scovill Mfg. Co., Mill Products Div., (Ad p 125-6)
99 Mill St., Waterbury 20, Conn.
Scranton Plastic Laminating Corp., 3213 Pittston Ave., Scranton 5, Pa.
Screw Products Co., 2909 Logan St., Lansing 17, Mich.
Scudder, E.J. Foundry & Machine Co. Canal & Pearl Sts., Trenton 9, N.J.
Scullin Steel Co., 6700 Manchester Ave., St. Louis 10, Mo.
Seal-Peel, Inc., 755 Stephenson Hwy., Royal Oak 3, Mich.
Sealube Co., 14 Valley St., Wakefield, Mass.
Sealview Plastics, Inc., 1010 Ford St., West Conshohocken, Pa.
Seaman Products, 120 W Providencia Ave., Burbank, Calif.
Seamless Rubber Co., 464 Congress St., New Haven 3, Conn.
Seaporcel Metals, Inc., 28-20 Borden Ave., Long Island City, N.Y.
Searjeant Metal Products, Inc., Mendon-Pittsford Rd., Mendon, N.J.
Seattle Boiler Works, Inc., 5237 E Marginal Way, Seattle, Wash.
Security Sash & Screen Co., 20096 James Couzens Hwy., Detroit 35, Mich.
Seiberling Rubber Co., Plastics Div., Newcomerstown, Ohio
Selma Foundry & Machine Co., P.O. Box 662, Selma, Ala.
Sel-Rex Corp., (Ad p 285)
75 River Rd., Nutley 10, N.J.
Seltzer, George H. & Co., Ridley & B & O RR, P.O. Box 66, Folsom, Pa.
Semon Bache & Co., 636 Greenwich St., New York 14, N.Y.
Seneca Wire & Mfg. Co., Fostoria, Ohio
Sequoia Metalcraft Co., Inc., 1001 Washington St., San Carlos, Calif.
Serrick Corp., Defiance, Ohio
Acme Machine Products Div., 1300 Batavia St., Muncie, Ind.
John Lees Div., 1300 Batavia St., Muncie, Ind.
Screw Machine Products Div., 731-22 Perry, Defiance, Ohio
Service Steel Co., 1435 Franklin St., Detroit 7, Mich.
Servwell Products Co., 6541 Euclid Ave., Cleveland 3, Ohio
Set Screw & Mfg. Co., 149 Main St., Bartlett, Ill.
Sewell Mfg. Co., 1019 E 10 Mile Rd., Hazel Park, Mich.
Seymour Mfg. Co., (Ad p 133)
Franklin St., Seymour, Conn.
Shakopee Foundry Co., Shakopee, Minn.
Shamban, W.S. & Co., 11617 W Jefferson Blvd., Culver City, Calif.
Shank Metal Products Co., 347 Madison Ave., New York 17, N.Y.
Sharon Steel Corp., Sharon, Pa.
Brainard Steel Div., Griswold St., Warren, Ohio
Sharpsville Steel Fabricators, Inc., 6th & Main Sts., Sharpsville, Pa.
Shaw Insulator Co., 160 Coit St., Irvington 11, N.J.
Shawinigan Resins Corp., 644 Monsanto Ave., Springfield 1, Mass.
Shaw-Kendall Engineering Co., 120 S Superior St., P.O. Box 1736, Toledo 3, Ohio
Sheet Metal Mfg. Co., 6400 Southern Blvd., Youngstown 20, Ohio
Sheffield Foundry Co., 2070 Clybourn Ave., Chicago 14, Ill.
Shelby Instrument Co., 1701 Magnolia Ave., Long Beach, Calif.
Shelby Mfg. Co., E Russel Rd., Sidney, Ohio
Shell Chemical Corp., 50 W 50th St., New York 20, N.Y.
Sheller Mfg. Corp., 8-159 General Motors Bldg., Detroit 2, Mich.
Dryden Rubber Div., 1014 S Kildare Ave., Chicago 24, Ill.
Shenango Furnace Co., Centrifugally Cast Products Div., Dover, Ohio
Shenango Refractories, P.O. Box 120, New Castle, Pa.
Sherman & Reilly, Inc., 1st & Broad Sts., Chattanooga, Tenn.
Sherwin-Williams Co., 101 Prospect Ave., NW, Cleveland 1, Ohio
Shieldalloy Corp., West Blvd., New Field, N.J.
Shingle Leather Co., 1300 Walnut St., Camden 3, N.J.
Shoe Form Co., Inc., Aurelius Ave., Auburn, N.Y.
Shriver, T. & Co., Inc., 390 Hamilton St., Harrison, N.J.
Shull Bros. Glass Co., 509 N 6th St., Millville, N.J.
Shur-Lok Corp., 879 S East St., Anaheim, Calif.
Sibley Machine & Foundry Corp., 206 E Tutt St., South Bend 23, Ind.
Sierra Electronic Corp., 15100 S Figueroa St., Gardena, Calif.
Simmons Fastener Corp., (Ad pp 396-7)
N Broadway, Albany 1, N.Y.
Simon Products Co., 3211 W Grand St., Chicago 51, Ill.
Simonds Saw and Steel Co., 470 Main St., Fitchburg, Mass.
Simonsen Metal Products Co., 4444 W Chicago, Chicago 51, Ill.
Sinclair Co., 60 Appleton St., Holyoke, Mass.
Sinko Mfg. & Tool Co., 7310 W Wilson Ave., Chicago 31, Ill.
Sintercast Corp. of America, 134 Woodworth Ave., Yonkers 2, N.Y.
Sintered Metals, Inc., 3390 Washington St., Jamaica Plain 30, Mass.
Sioux City Foundry & Boiler Co., E 8th & Division Sts., Sioux City 2, Iowa
Sipe Metals Corp., 1720 N Elston Ave., Chicago 22, Ill.
Sivyer Steel Casting Co., 43rd & Mitchell Ave., Milwaukee 14, Wis.
Skookum Co., Inc., 8504 W Crawford St., Portland 3, Ore.
Skyline Industries, Titusville 1, Pa.
Small Tube Products, Inc., Main St., Waterbury, Conn.
Smith, A.O. Corp., 3533 N 27th St., Milwaukee 1, Wis.
Smith, A.P. Mfg. Co., 500 N Arlington Ave., East Orange, N.J.
Smith, Nowery J. Bolt & Supply Co., P.O. Box 7398, Houston 8, Tex.
Smith Chemical & Color Co., Inc., 55 John St., Brooklyn 1, N.Y.
Smith & Winchester Mfg. Co., South Windham, Conn.
Smith-Armstrong Forge, Inc., 1209 Marquette Rd., Cleveland 14, Ohio
Smithers Tool & Machine Products, Inc., 645 Broadway, Red Hook, N.Y.
Smith-Moon Steel Co., Inc., Courier Bldg., Winfield, Kan.
Smith-Victor Corp., Griffith, Ind.
Smoot-Holman Co., 321 N Eucalyptus Ave., Inglewood, Calif.
Snyder Mfg. Co., Inc., 1458 5th St. NW, New Philadelphia, Ohio
Snyder, M.L. & Son, Inc., Jasper & York Sts., Philadelphia 15, Pa.
Solar Aircraft Co., 2200 Pacific Hwy., San Diego 12, Calif.
Solon Foundry, Inc.. 6370 SOM Center Rd., Solon, Ohio
Somerset Foundry & Machine Co., 809-831 Edgewood Ave., Somerset, Pa.
Somers Brass Co., Inc., (Ad pp 136, 139)
94 Baldwin Ave., Waterbury 20, Conn.
Sommer Metalcraft Corp., 315 Poston Dr., Crawfordsville, Ind.
Sonith Foundries, Food Machinery Corp., 50 Shelby St., Indianapolis 6, Ind.
Sonken-Galamba Corp., 2nd & Riverview, Kansas City 18, Kan.
Sorbo-Cast Corp., New Brunswick, N.J.
Sorbo-Mat Process Engineers, (Ad p 335)
106 S Hanley St., St. Louis 5, Mo.
South Chester Corp., Southco Div., Lester, Pa.
South River Metal Products Co., Inc., 377 Turnpike, South River, N.J.
Southern Adhesives Corp., 1501 W Moore St., Richmond, Va.
Southern Aluminum Finishing Co., Inc., 1581 Huber St., NW, Atlanta 18, Ga.
Southern Asbestos Co., 1000 Seaboard Rd., Charlotte, N.C.
Southern Belting & Transmission Co., P.O. Box 4296, Atlanta 2, Ga.
Southern Car & Mfg. Co., Inc., 1831 29th Ave. N, Birmingham, Ala.
Southern Galvanizing Co., 1620 Bush St., Baltimore 30, Md.
Southern Metal Products Co., 4444 N Miro St., New Orleans 17, La.
Southern Plastics Co., 408 Pendelton St., Columbia, S.C.
Southern Screw Co., P.O. Box 1360, Statesville, N.C.
Southwestern Plastic Pipe Co., P.O. Box 117, Mineral Wells, Tex.
Southwestern Porcelain Steel Corp., P.O. Box 607, Sand Springs, Okla.
Spaulding Fibre Co., Inc., (Ad p 217)
310 Wheeler St., Tonawanda, N.Y.
Special Leathers Co., 1920 E Venango St., Philadelphia 34, Pa.
Special Screw Products Co., 5445 Dunham Rd., Bedford, Ohio
Specialty Resins Co., 2801 Lynwood Rd., Lynwood, Calif.
Speer Carbon Co., St. Marys, Pa.
Spencer Chemical Co., Dwight Bldg., 1004 Baltimore Ave., Kansas City 5, Mo.
Spencer Nahm Co., 765 1st Ave., San Leandro, Calif.
Spencer's Sons, I.S. Inc., 20 Fair St., Guilford, Conn.
Spincraft, Inc., 4122 W State St., Milwaukee 8, Wis.
Spiral-Glas Pipe Co., 47 Bayard St., New Brunswick, N.J.
Spraylat Corp., (Ad p 278)
1 Park Ave., New York 16, N.Y.
Spring City Foundry Co., Hall & Main Sts., Spring City, Pa.
Spring Packing Corp., 332 S Michigan Ave., Chicago 4, Ill.
Springer's Foundry Co., Inc., 201 S 1st St., Terre Haute, Ind.
Springfield Foundry Co., 295 Pasco Rd., Indian Orchard, Mass.
Spruce Pine Mica Co., Inc., P.O. Box 456, Spruce Pine, N.C.
Spuck Iron & Foundry Co., 3145 N 14th St., St. Louis 7, Mo.
Stacey Mfg. Co., Township Ave., & Big Four RR, Cincinnati 16, Ohio
Stackpole Carbon Co., (Ad p 248)
St. Marys, Pa.

Addresses of Suppliers

Stainless Foundry & Engineering, Inc., 5132 N 35th St., Milwaukee 9, Wis.
Stainless Metals, Inc., 19-42 42nd St., Long Island City 1, N.Y.
Stalwart Rubber Co., 160 Northfield Rd., Bedford, Ohio
Stamford Metal Specialty Co., Inc., 429 W Broadway, New York 12, N.Y.
Stamford Rolling Mills Co., Inc., Springdale, Conn.
Standard Asbestos Mfg. Co., 860 W Evergreen Ave., Chicago 22, Ill.
Standard Casting Corp., 4400 W Cormak Rd., Chicago 23, Ill.
Standard Felt Co., 24-115 S Palm Ave., Alhambra, Calif.
Standard Forge & Axle Co., Inc., P.O. Box 309, Montgomery 1, Ala.
Standard Foundry Co., Southgate & Armory Sts., Worcester 10, Mass.
Standard Insulation Co., Plastics Div., 74 Paterson Ave., East Rutherford, N.J.
Standard Locknut & Lockwasher Inc., 2250-56 Valley Ave., Indianapolis 18, Ind.
Standard Magnesium Corp., 7500 E 41st St., Tulsa, Okla.
Standard Metals Corp., 262 Broad St., North Attleboro, Mass.
Standard Nut & Bolt Co., Abbott St., Valley Falls, R.I.
Standard Plastics Co., 62 Water St., Attleboro, Mass.
Standard Pressed Steel Co., Box 888, Jenkintown, Pa.
Standard Products Co., 316 Fisher Bldg., Detroit, Mich.
Standard Screw Co., Wilson, Conn.
Chicago Screw Co., 2701 Washington Blvd., Bellwood, Ill.
Hartford Machine Screw Co., P.O. Box 1440, Hartford 2, Conn.
Western Automatic Machine Screw Co., 377 Woodland Ave., Elyria, Ohio
Standard Screw Products Co., 506 S Palm Ave., Alhambra, Calif.
Standard Stamping & Perforating Co., 3129 W 49th Place, Chicago 32, Ill.
Standard Steel Sections, Inc., 608 E 133rd St., New York, N.Y.
Standard Tube Co., 24400 Plymouth Rd., Detroit 39, Mich.
Standard Washer & Mat, Inc., 155 Adams St., Manchester, Conn.
Stanley Chemical Co., Berlin St., East Berlin, Conn.
Stanley Works, Stanley Industrial Sales Div., 195 Lake St., New Britain, Conn.
Stanwood Corp., 4819 Cortland, Chicago 39, Ill.
Star Expansion Industries Corp., Pleasant Hill Rd., Mountainville, N.J.
Star Heel Plate Co., Inc., 12 Thornton St., Newark 5, N.J.
Star Porcelain Co., Muirhead Ave., Trenton, N.J.
Star Stamping Co., 1303 M-139, Benton Harbor, Mich.
Star Wire Screen & Iron Works Inc., 2515 San Fernando Rd., Los Angeles 65, Calif.
Star Woolen Co., Cohoes, N.Y.
State Foundry & Machine Co., Cedar Grove, Wis.
Staver Co., Inc., 49 N Saxon Ave., Bay Shore, N.Y.
Stearns-Roger Mfg. Co., 660 Bannock St., Denver, Colo.
Steel Fabricators Co., 1252-B Spruce St., Cleveland 13, Ohio
Steel Heddle Mfg. Co., 2100 Wallegheny Ave., Philadelphia 32, Pa.
Steel Improvement and Forge Co., 970 E 64th St., Cleveland, Ohio
Steel Industries, Inc., 907 Louise Ave., Crawfordsville, Ind.
Steel Protection & Chemical Co., Mooresville, Ind.
Steel Shot Producers, Inc., 4389 Harrison St., Pittsburgh 1, Pa.
Steel, R. & Sons, Inc., 42-21 9th St., Long Island City 1, N.Y.
Steelcote Mfg. Co., 3418 Gratiot St., St. Louis 3, Mo.
Steinen, William Mfg. Co., 43 Bruen St., Newark 5, N.J.
Stella Products Corp., 66 Okner Pky., Livingston, N.J.
Stenman, Bror F., West St., Auburn, Mass.
Sterling Aluminum Products, Inc., 2600 N 3rd St., St. Charles, Mo.
Sterling Brass Foundry, Inc., 1640 Sterling Ave., Elkhart, Ind.
Sterling Die Casting Co., 743 39th St., Brooklyn 32, N.Y.
Sterling Foundry Co., 8 Wallace St., Sterling, Ill.
Sterling Models, Belford Ave. & Wister, Philadelphia, Pa.
Sterling Molders, Inc., 277 Military Rd., Buffalo 7, N.Y.
Sterrit-Thomas Foundry Co., 32nd & Smallman St., Pittsburgh 1, Pa.
Stevens, Frederic B., Inc., 1800 18th St., Detroit, Mich.
Stevens, J.P. & Co., Inc., 1460 Broadway, New York 36, N.Y.
Steward, D.M. Mfg. Co., (Ad p 362)
E 36th St., Chattanooga, Tenn
Stewart-Warner Corp., Stewart Die Casting Div., 4535 W Fullerton Ave., Chicago 30, Ill.
Stillman White Foundry Co., Inc., 42 Dodge St., Providence, R.I.
Stimpson, Edwin B. Co., Inc., 70 Franklin Ave., Brooklyn 5, N.Y.
Stirrup Metal Products Corp., 215 Emmet St., Newark 5, N.J.
Stockwell Rubber Co., Inc., 1117 Shackamaxon St., Philadelphia 25, Pa.
Stone Straw Corp., Stone Paper Tube Div., 900 Franklin St., NE, Washington 17, D.C.
Stoody Co., Whittier, Calif.
Stover Steel Tank & Mfg. Co., 100 S Hancock Ave., Freeport, Ill.
Stranahan Foil Co., Inc., 100 Wesley St., South Hackensack, N.J.
Strick Plastics Co., Perkasie, Pa.
Strong Steel Foundry Co., 33 Norris St., Buffalo 7, N.Y.
Struthers Wells Corp., 30 Rockefeller Plaza, New York 20, N.Y.
Stuart Foundry Co., 138 S Junction St., Detroit, Mich.
Stulz-Sickles Co., 929-939 Port Ave., at Julia St., Elizabeth, N.J.
Subax, Inc., Fairmount Plant, Hackensack, N.J.
Sun Chemical Corp., 10th St. & 44th Ave., Long Island City 1, N.Y.
Electro Chemical Corp., 113 E Centre St., Nutley 10, N.J.
Horn, A.C. Co., Inc., 750 3rd Ave., New York 17, N.Y.
Sun Rubber Co., 366 Fairview Ave., Barberton, Ohio
Sun Steel Co., Special Products Div., 1700 W 74th Pl., Chicago 36, Ill.
Sun Tube Corp., 181 Long Ave., Hillside, N.J.
Sunlite Plastics, Inc., 1512 W Pierce St., Milwaukee, Wis.
Superb Light Alloys, Inc., Allen Blvd., Farmingdale, N.Y.
Superior Carbon Products, Inc., 9115 George Ave., Cleveland 5, Ohio
Superior Die Casting Co., 1001 London Rd., Cleveland 10, Ohio
Superior Drawn Steel Co., Beaver Ave., Monaca, Pa.
Superior Foundry, Inc., 3542 E 71st St., Cleveland 5, Ohio
Superior Industries, Inc., 3786 Oakwood Ave., Youngstown 9, Ohio
Superior Plastics, Inc., 426 N Oakley Blvd., Chicago 12, Ill.
Superior Plating, Inc., 1064 10th Ave. SE, Minneapolis, Minn.
Superior Spinning & Stamping Co., 4057-63 Fitch Rd., Toledo 13, Ohio
Superior Steel Corp., Carnegie, Pa.
Superior Steel & Malleable Castings Co., Benton Harbor, Mich.
Superior Tube Co., Box 191, Norristown, Pa.
Superior-Pacific Galvanizing Co., 1711 E 61st St., Los Angeles 1, Calif.
Supreme Industrial Products Co., 367 N Karlov Ave., Chicago 24, Ill.
Surprenant Mfg. Co., 199 Washington St., Boston 8, Mass.
Swayne-Robinson & Co., 210 Main St., Richmond, Ind.
Swedish Crucible Steel Co., 8801 Conant Ave., Detroit 11, Mich.
Swedlow Plastics Co., 6986 Bandini Blvd., Los Angeles, Calif.
Swedlow Plastics Corp., 394 N Meridian Rd., Youngstown, Ohio
Sweet's Steel Co., 6666 Sweet St., Williamsport, Va.
Swepco Tube Corp., 1 Clifton Blvd., Clifton, N.J.
Swett, A.L. Iron Works, 172 Glenwood Ave., Medina, N.Y.
Sylvan Plastics Inc., 1617 Pennsylvania Ave., Philadelphia 3, Pa.
Sylvania Electric Products, Inc., 1740 Broadway, New York 19, N.Y.
Chemical & Metallurgical Div., Towanda, Pa.
Parts Div., (Ad p 349)
Warren, Pa.
Symington-Gould Corp., Depew, N.Y.
Synco Resins, Inc., Henry St., Bethel, Conn.
Synthane Corp., (Ad p 200)
River Rd., Oaks, Pa.

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Tallman-McCluskey Fabrics Co., 230 E Monroe, Kirkwood 22, Mo.
Taylor & Co., Inc., 680 Morgan Ave., Brooklyn 22, N.Y.
Taylor & Boggis Foundry, 1290 E 53rd St., Cleveland, Ohio
Taylor Fibre Co., (Ad p 194)
Box 471, Norristown, Pa.
Taylor Forge & Pipe Works, P.O. Box 485, Chicago 90, Ill.
Techalloy Co., Inc., Rte. 113, Rahns 5, Pa.
Technical Plywood Sales, 6750 Crandon Ave., Chicago 49, Ill.
Technical Specialties Co., 415 Concord Ave., New York 55, N.Y.
Technical Tape Corp., 240 North Ave., New Rochelle, N.Y.
Teiner, Roland Co., Inc., 134 Tremont St., Everett 49, Mass.
Temco, Inc., 4101 Charlotte Ave., Nashville, Tenn.
Terre Haute Bronze & Brass Foundry, 1114 Sycamore St., Terre Haute, Ind.
Terre Haute Malleable & Mfg. Corp., 2030 N 19th St., Terre Haute, Ind.
Testor Chemical Co., 600 Buckbee, Rockford, Ill.
Texas Aluminum Co., Inc., 1218 Mercantile Securities Bldg., Dallas, Tex.
Texas Foundries, Inc., P.O. Box 180, Lufkin, Tex.
Texas Glass Fiber Corp., 147 Island Grove Rd., Grandview, Tex.
Texas Plastic Development Corp., 2120 Post Oak Rd., Houston, Tex.
Texas Steel Co., 3901 Hemphill St., Fort Worth 9, Tex.
Texas-U. S. Chemical Co., (Ad pp 218-219)
260 Madison Ave., New York, N.Y.
Textile Shield Co., Inc., 1 Groton St., Lawrence, Mass.
Textron, Inc., 50 S Main, Providence, R.I.
Burkart, F. Mfg. Co., 4900 N 2nd St., St. Louis 7, Mo.
Campbell, Wyant & Cannon Foundry Co., Henry St., Muskegon, Mich.
Textron Metals Co., 39 James St., Girard, Ohio
Thalco, 765 S Harvard Blvd., Los Angeles, Calif.
Thermaflow Chemical Corp., Box 115, Tunkhannock, Pa.
Thermal American Fused Quartz Co., 18 Salem St., Dover, N.J.
Thermal Refractories Corp., 4501 Dell Ave., North Bergen, N.J.
Thermo Materials, Inc., 4040 Campbell Ave., Menlo Park, Calif.
Thinsheet Metals Co., 271-TR Railroad Hill St., Waterbury 20, Conn.
Thiokol Chemical Corp., 780 N Clinton Ave., Trenton 7, N.J.
Thombert, Inc., 316 E 7th St., N, Newton, Iowa
Thompson and Co., 1085 Allegheny Ave., Oakmont, Pa.
Thompson, H.I. Fiber Glass Co., 1733 Cordova St., Los Angeles 7, Calif.
Thompson Industries, Inc., Manhasset, N.Y.
Thompson Pipe & Steel Co., 308 Larimer St., P.O. Box 2852, Denver 1, Colo.
Thompson Products, Inc., 23555 Euclid Ave., Cleveland 17, Ohio
Light Metals Div., 2269 Ashland Rd., Cleveland, Ohio
Kolcast Industries Div., 16801 Euclid Ave., Cleveland 12, Ohio
Valve Div., 1455 E 185th St., Cleveland 10, Ohio
Thompson, K.W. Tool Co., 20 Dexton Ave., New Hyde Park, N.Y.
Thompson Wire Co., 41 Mildred Ave., Boston 26, Mass.
Thompson-Bremer & Co., 228 N La Salle St., Chicago 1, Ill.
Thomson, Judson L. Mfg. Co., Sawyer Rd., Waltham, Mass.
Thys Co., 6900 Folsom Blvd., Sacramento 19, Calif.
Tiarco Corp., Box 766, Clark, N.J.
Tickle, Arthur Engineering Works, Inc., (Ad p 290)
21 Delevan St., Brooklyn 31, N.Y.
Timber Products Co., P.O. Box 1032, Medford, Ore.
Timken Roller Bearing Co., Steel & Tube Div., 1835 Dueber Ave., SW Canton 6, Ohio
Tinnerman Products, Inc., Dept. 16, P.O. Box 6688, Cleveland 1, Ohio
Titan Metal Mfg. Co., Bellefonte, Pa.
Titanium Metals Corp. of America, 233 Broadway, New York 7, N.Y.
Titchener, E. H. & Co., 67 Clinton St., Binghamton, N.Y.
Toepfer & Sons, Inc., 2925 W Hope Ave., Milwaukee 16, Wis.
Toledo Industrial Rubber Co., 2242 Smead Ave., Toledo 6, Ohio
Toledo Stamping & Mfg. Co., 99 Fearing Blvd., Toledo 7, Ohio
Tompkins Products, 1040 W Grand Blvd., Detroit 8, Mich.
Tool & Mfg. Co., Inc., P.O. Box 10344, Pittsburgh 34, Pa.
Topeka Foundry & Iron Works Co., Inc., 300-324 Jackson St., Topeka, Kan.
Torngren, C.W. Co., Inc., 236 Pearl St., Somerville 45, Mass.
Torrington Co., 59 Field St., Torrington, Conn.
Tousey Varnish Co., 520 W 25th St., Chicago 16, Ill.
Tower Grove Foundry, 4438 Hunt Ave., St. Louis 10, Mo.
Townsend Co., P.O. Box 237, New Brighton, Pa.
Toyad Co., Plant Blvd., Latrobe, Pa.
Trane Co., 206 Cameron Ave., La-Crosse, Wis.

Transue & Williams Steel Forging Corp., 562 W Ely St., Alliance, Ohio
Trenton Brass Co., 621 Prospect St., Trenton, N.J.
Triangle Conduit & Cable Co., Inc., 6900 Jersey Ave., New Brunswick, N.J.
Triangle Stamping Co., 5101 Carnegie Ave., Cleveland 3, Ohio
Trigon Specialties Corp., 1005 S Lafayette Blvd., South Bend 18, Ind.
Trim Alloys, Inc., 30-40 W 3rd St., Boston 27, Mass.
Tri-Point Mfg. & Developing Co., 171 I. U. Willets Rd., Alberton, L.I., N.Y.
Trojan Steel Co., P.O. Box 2426, Charleston 29, W. Va.
Troy Blanket Mills, 200 Madison Ave., New York, N.Y.
Trucke Leather Co., Peabody, Mass.
True Alloys, Inc., 284 S Summit St., Detroit 9, Mich.
Tube Distributors Co., Inc., 1415 Kellum Pl., Garden City, N.Y.
Tube Methods, Inc., Depot & Rambo Sts., Bridgeport, Pa.
Tube Reducing Corp., 520 Main Ave., Wallington, N.J.
Tube Turns Plastics, Inc., 2929 Magazine St., Louisville 11, Ky.
Tubular Rivet & Stud Co., Weston Ave., Wollaston 70, Mass.
Turco Products, Inc., 6135 S Central Ave., Los Angeles 1, Calif.
Turner Halsey Co., 40 Worth St., New York 13, N.Y.
Turner & Seymour Mfg. Co., Lawton St., Torrington, Conn.
Twin City Die Castings Co., Talmage & 33rd Aves., SE, Minneapolis 14, Minn.
Twitchell, E.W. Inc., 2806 N 3rd St., Philadelphia 33, Pa.
Tyler, W.S. Co., 3615 Superior Ave., Cleveland 14, Ohio

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UBS Chemical Corp., 491 Main St., Cambridge 43, Mass.
Udylite Corp., 1651 Grand Blvd., Detroit 11, Mich.
Ulbrich Stainless Steels Corp., Old Colony Rd., Wallingford, Conn.
Ullmann, Inc., 4305 N 127th St., Butler, Wis.
Uniform Tubes, Inc., Level & School Rds., Collegeville 2, Pa.
Union Asbestos & Rubber Co., 1111 W Perry St., Bloomington, Ill.
Union Carbide Corp., 30 E 42nd St., New York 17, N.Y.
Bakelite Div., 30 E 42nd St., New York 17, N.Y.
Electro Metallurgical Co., Div., (Ad p 134)
535 5th Ave., New York 17, N.Y.
Haynes Stellite Co. Div., 725 S Lindsay St., Kokomo, Ind.
Linde Co. Div., (Ad p 400)
30 E 42nd St., New York 17, N.Y.
National Carbon Div., 30 E 42nd St. New York 17, N.Y.
Silicones Div., 30 E 42nd St., New York 17, N.Y.
Union Chemical Corp., 410 Frelinghuysen Ave., Newark 5, N.J.
Union Forging Co., 500 North St., Endicott, N.Y.
Union Iron Works, P.O. Box 2135, Spokane, Wash.
Union Paste Co., 1805 Hyde Park Ave., Hyde Park 36, Mass.
Union Screw & Mfg. Co., Box 25, Imperial, Pa.
Union Spring & Mfg. Co., 2nd Ave. & 8th St., New Kensington, Pa.
Union Steel Corp., Stanley Terrace, Union, N.J.
Union Tank Car Co., 228 N LaSalle, Chicago, Ill.
Unitcast Corp., (Ad p 330)
Water Works Dr., Toledo 9, Ohio
United Carbon Products Co., 1310 N Madison St., Bay City, Mich.
United Cork Cos., 15 Central Ave., Kearney, N.J.
United Forge Co., 277 Dubois, Detroit 7, Mich.
United International Research, Inc., 38-15 30th St., Long Island City 1, N.Y.
United Metal Products Corp., 8101 Lyndon Ave., Detroit 38, Mich.
United Rubber & Chemical Co., P.O. Box 1913, Charleston 27, W. Va.
United Screw & Bolt Corp., 2513 W Cullerton Ave., Chicago 8, Ill.
United Shoe Machinery Corp., 140 Federal St., Boston 7, Mass.
United Sintered Alloys, St. James, L.I., N.Y.
United Smelting & Aluminum Co., Inc., 187 Commerce St., New Haven 9, Conn.
U.S. Bronze Powder Works, Inc., Rt. No. 202, Flemington, N.J.
U.S. Ceramic Tile Co., Sparta Mfg. Co., Dover, Ohio
U.S. Challenge & Challenge Co., 1441 N Kingsburg St., Chicago 22, Ill.
U.S. Extrusions Corp., 120 Old Broadway, Garden City Park, N.Y.
U.S. Gasket & Shim Co., 2743 2nd St., Cuyahoga Falls, Ohio
U.S. Gypsum Co., 300 W Adams St., Chicago 6, Ill.
U.S. Magnesium Co., Pleasant Valley, N.Y.
U.S. Metal Products Co., P.O. Box 1067, Erie, Pa.
U.S. Mica Co., Inc., 1525 Circle Ave., Forest Park, Ill.
U.S. Pipe and Foundry Co., 3300 1st Ave. N, Birmingham 3, Ala.
U.S. Plywood Corp., 55 W 44th St., New York 36, N.Y.
U.S. Polymeric Chemicals, Inc., Box 546, Stamford, Conn.
U. S. Reduction Co., Chicago Ave. & Melville St., East Chicago, Ind.
U. S. Rubber Co., 1230 Ave. of the Americas, New York 20, N.Y.
Mechanical Goods Div., 4300 New Haven Ave., Fort Wayne, Ind.
Naugatuck Chemical Div., Elm St., Naugatuck, Conn.
Kem-Blo Dept. (Ad p 216)
Naugatuck, Conn.
U. S. Smelting, Refining & Mining Co., 62 William St., New York, N.Y.
U. S. Steel Corp., (Ad p 77)
525 William Penn Pl., Pittsburgh 30, Pa.
American Steel & Wire Div., Rockefeller Bldg., Cleveland 13, Ohio
Irvin Works, Dravosburg, Pa.
National Tube Div., 525 William Penn Pl., Pittsburgh 30, Pa.
Oil Well Supply Div., 2001 N Lamar St., Dallas 2, Tex.
U. S. Stoneware Co., P.O. Box 350, Akron 9, Ohio
U.S. Valve & Mfg. Co., 256 E Grand Ave., South San Francisco, Calif.
United Wire & Supply Corp., 1497 Elmwood Ave., Providence 7, R.I.
United-Carr Fastener Corp., 31 Ames St., Cambridge 42, Mass.
Unity Machine & Tool Corp., 2727 E Westmoreland St., Philadelphia 34, Pa.
Universal Castings Corp., 5821 W 66th St., Chicago 38, Ill.
Universal Converting Corp., 1125 County St., New Bedford, Mass.
Universal Unlimited, Inc., Pratt Oval, Glen Cove, N.Y.
Universal-Cyclops Steel Corp., Bridgeville, Pa.
Empire-Reeves Steel Div., Bridgeville, Pa.
University of Tennessee, Dept of Chemistry, University Sta., Knoxville 16, Tenn.
Uniworld Research Corp. of America, 1302 Ontario, Cleveland 12, Ohio
Urrite Plastics Fabricators, 4740-2 S Durfee Rd., Pico, Calif.
Utica Drop Forge & Tool Co., 2409-15 Whitesboro St., Utica 4, N.Y.
Utica General Jobbing Foundry, Inc., 1801 Foundry St., Utica 3, N.Y.
Utica Radiator Corp., Dwyer Ave., Utica, N.Y.
Utility Mfg. Co., 2443 Boston Rd., North Wilbraham, Mass.
Utility Steel Foundry, 3320 E Slauson, Vernon, Calif.

V

Valley Iron Works, 81 E Water St., St. Paul 7, Minn.
Valley Steel Casting Co:, Foot of 11th St., Bay City, Mich.
Valley-National Corp., Clark St., Milldale, Conn.
Vanadium-Alloys Steel Co., Latrobe, Pa.
Anchor Drawn Steel Co., Latrobe, Pa.
Colonial Steel Div., Monaca, Pa.
Vanamatic Co., 204 S Jefferson St., Delphos, Ohio
Van der Horst Corp., Olean, N.Y.
Van Huffell Tube Corp., Larchmont Ave., NE, Warren, Ohio
Van Pelt Corp., Service Steel Div., Box 532, Detroit 32, Mich.
Van Valkenburg, L.D. Co., Box 190, Holyoke, Mass.
Vanadium Corp. of America, (Ad p 69)
420 Lexington Ave., New York 17, N.Y.
Vandersee Corp., 1414 Chestnut Ave., Hillside, N.J.
Varcum Chemical Corp., P.O. Box 476, Niagara Falls, N.Y.
Varflex Corp., 512 W Court St., Rome, N.Y.
Variety Stamping Corp., 12695 Elmwood Ave., Cleveland 11, Ohio
Veeder-Root Inc., 70 Sargeant St., Hartford 2, Conn.
Vellumoid Co., 54 Rockdale St., Worcester 6, Mass.
Veremere, E.A. Inc., 11623 S Broadway, Los Angeles 61, Calif.
Victor Equipment Co., 844 Folsom St., San Francisco 7, Calif.
Victor Mfg. & Gasket Co., 5750 W Roosevelt Rd., Chicago 50, Ill.
Victor Steel Products Corp., 1175 Leggett Ave., New York 59, N.Y.
Victory Plastics Co., 81 Apsley St., Hudson, Mass.
Viking Copper Tube Co., 16700 St. Clair Ave., Cleveland, Ohio
Viking Pump Co., George & Wyth Sts., Cedar Falls 1, Iowa
Viplax Products Corp., 408 E Warren St., Beverly, N.J.
Visking Corp., Fabrics Div., 1313 E 8th St., North Little Rock, Ark.
Plastics Div., P.O. Box 1410, Terre Haute, Ind.
Vogt Mfg. Corp., 100 Fernwood Ave., Rochester, N.Y.
Volco Brass & Copper Co., Childs Rd., Basking Ridge, N.J.
Vollrath Co., Contract Div., 1236 N 18th St., Sheboygan, Wis.
Vulcan Foundry Co., Oakland, Calif.
Vulcan Iron Works, 730 S Main St., Wilkes Barre, Pa.
Vulcan Mfg. Co., 120 Sycamore St., Cincinnati 2, Ohio
Vulcan Metal Products, Inc., 2801 6th Ave., S, Birmingham, Ala.
Vulcan Rail & Construction Co., 59-30 54th St., Maspeth, N.Y.
Vulcanized Rubber & Plastics Co., 5 S Pennsylvania Ave., Morrisville, Pa.

W

W. F. Mfg. Co., 1509 Gardena Ave., Glendale 4, Calif.
WLS Stamping Co., 3292 E 80th St., Cleveland 4, Ohio
Wabash Metal Products Co., Inc., P.O. Box 305, Wabash, Ind.
Wagner Malleable Iron Co., 1275 E Sangamon, Decatur, Ill.
Wagner, E.R. Mfg. Co., 4611 N 32nd St., Milwaukee 9, Wis.
Wagner Plastic Corp., Rte. 88, Lakewood, N.J.
Wagner Specialty Co., 647 Dodge St., Burlington, Wis.
Wah Chang Corp., 233 Broadway, New York 7, N.Y.
Waimet Alloys Co., (Ad p 72)
1999 Guoin St., Detroit 7, Mich.
Wakefield Bearing Corp., 45 Foundry St., Wakefield, Mass.
Waldes Kohinoor, Inc., 47-16 Austel Pl., Long Island City 1, N.Y.
Walker Forge, Inc., 2000 17th St., Racine, Wis.
Wall Colmonoy Corp., Stainless Process Div., (Ad p 402)
19345 John R. St., Detroit 3, Mich.
Wall, P. Mfg. Co., Erie St., Grove City, Pa.
Wall Tube & Metal Products Co., P.O. Box 330, Newport, Tenn.
Wallace Supplies Mfg. Co., Wallace Tube Co. Div., 1300 Diversey Pkwy., Chicago 14, Ill.
Wallingford Steel Co., (Ad p 352)
80 Valley St., Wallingford, Conn.
Wal-Mar Corp., 2800 Bernice Rd., Lansing, Ill.
Walrod Machine Products, 5225 SE 7th Ave., Portland 2, Ore.
Walsen Consolidated Mercantile Co., 2 Broadway, New York 4, N.Y.
Waltham Foundry Co., 71 Felton St., Waltham 54, Mass.
Ward, H.H. Co., 4th & Engle Sts., Chester, Pa.
Warner Mfg. Corp., 265 Watsessing Ave., Bloomfield, N.J.
Warren Belting Co., 33 Arctic St., Worcester 8, Mass.
Warren Bros. Roads Co., 32 Potter St., Cambridge 42, Mass.
Washburn Wire Co., Phillipsdale Div., Bourne Ave., Phillipsdale, R.I.
Washington Iron Works, 1500 6th Ave., S, Seattle 4, Wash.
Washington Mfg. Co., Inc., P.O. Box 370, Washington, Iowa
Washington Steel Corp., 1001 Berger Bldg., Washington, Pa.
Waterbury Buckle Co., 952 S Main St., Waterbury 20, Conn.
Waterbury Cos., Inc., (Ad p 327)
P.O. Box 1032, Waterbury, Conn.
Waterbury Pressed Metal Co., 300 Chase Ave., Waterbury 14, Conn.
Waterbury Rolling Mills, Inc., (ad p 129)
Box 550, Waterbury 20, Conn.
Waterman Industries, Inc., 515 S. G St., Exeter, Calif.
Watertown Mfg. Co., Echo Lake Rd., Watertown, Conn.
Watson-Standard Co., 225 Galveston Ave., Pittsburgh 12, Pa.
Waukesha Foundry Co., (Ad p 350)
Lincoln Ave.,Waukesha, Wis.
Wayne Agricultural Works, Inc., Goldsboro, N.C.
Wayne Chemical Products Co., 9470 Copland Ave., Detroit 17, Mich.
Wayne Foundry & Stamping Co., 3100 Hubbard St., Detroit 10, Mich.
Weatherhead Co., 128 W Washington Blvd., Fort Wayne 1, Ind.

Addresses of Suppliers

Weber-Knapp Co., 441 Chandler St., Jamestown, N.Y.
Webster Mfg., Inc., 1100 W Davis St., Tiffin, Ohio
Weckesser Co., 5713 Northwest Hwy., Chicago 30, Ill.
Wedler Bros., Inc., 1535 E 38th St., Cleveland 14, Ohio
Weiskittel, Harry C. Co., Inc., 4901 Pulaski Hwy., Baltimore 24, Md.
Welding Apparatus Co., 2750 W Van Buren St., Chicago 12, Ill.
Wellington Sears Co., 65 Worth St., New York 13, N.Y.
Wellman, S.K. Co., 20 Egbert Rd., Bedford, Ohio
Wellman Bronze and Aluminum Co., 12800 Shaker Blvd., Cleveland 20, Ohio
Wellman Engineering Co., 7004 Central Ave., Cleveland 4, Ohio
Wells, A.H. & Co., Inc., 100 E Aurora St., Waterbury, Conn.
Wellsville Fire Brick Co., Wellsville, Mo.
Werner, R.D. Co., Inc., (Ad p 346)
295 5th Ave., New York 16, N.Y.
Werner Foundry & Machine Co., 8th St. & Reading R.R., Lansdale, Pa.
Wesbar Stamping Corp., West Bend, Wis.
Wesco Spring Co., 4501 S Knox Ave., Chicago 32, Ill.
Wessels Co., 1625 E Euclid Ave., Detroit 11, Mich.
West Haven Foundry Co., 27 Kimberly Ave., West Haven, Conn.
West Irving Die Casting Co., 240 S Evergreen St., Bensenville, Ill.
West Steel Casting Co., 1679 Collamer Rd., Cleveland 10, Ohio
West Virginia Malleable Iron Co., Point Pleasant, W. Va.
Western Automatic Machine Screw Co., 377 Woodland Ave., Elyria, Ohio
Western Coating Co., Box 598, Oakridge Sta., Royal Oak 3, Mich.
Western Felt Works, (Ad p 249)
4115 W Ogden Ave., Chicago 23, Ill.
Western Foundry & Machine Works, Inc., 201 Jefferson St., Topeka, Kan.
Western Gold & Platinum Co., 525 Harbor Blvd., Belmont, Calif.
Western Iron & Foundry Co., Inc., 702 E 2nd St., Wichita 2, Kan.
Western Machine Co., 180 W Holt Ave., Milwaukee 7, Wis.
Western Plastics Corp., 1515 W 2nd St., Hastings, Neb.
Western Plastics Corp., 3110 Ruston Way, Tacoma 2, Wash.
Western Tool & Die Works, 421 NW 3rd Ave., Portland 9, Ore.
Westinghouse Electric Corp., 101 Liberty Ave., Gateway Center, Pittsburgh, Pa.
Materials Mfg. Dept., Blairsville, Pa.
Micarta Div., Hampton, S.C.
Westlake Plastics Co., 145 W Lenni Rd., Lenni Mills, Pa.
Westland Die Casting, Inc., 4617 Sperry St., Los Angeles 39, Calif.
Westlectric Castings, Inc., 2040 S Camfield Ave., Los Angeles 22, Calif.
Westmoreland Malleable Iron Co., Westmoreland, N.Y.
Weyerhaeuser Sales Co., Special Products Div., Tacoma Bldg., Tacoma 1, Wash.
Wheatland Tube Co., Bankers Securities Bldg., Philadelphia 7, Pa.
Wheaton Die Casting Corp., N 10th St., Millville, N.J.
Wheeling Steel Corp., 1134-40 Market St., Wheeling, W. Va.
Wheelock, Lovejoy & Co., Inc., 128 Sidney St., Cambridge 39, Mass.
Whitaker Metals Corp., 1301 Burlington St., North Kansas City 16, Mo.
White Metal Rolling & Stamping Corp., 80 Moultrie St., Brooklyn 22, N.Y.
White Sewing Machine Corp., Apex Reinforced Plastics Div., Elm & Washington Sts., Cleveland 13, Ohio
Whitehead Metal Products Co., Inc., 303 W 10th St., New York 14, N.Y.
Whitfield Chemical Co., 14225 Schaefer Hwy., Detroit 27, Mich.
Whitso, Inc., 9330 Byron St., Schiller Park, Ill.
Whyte, Oliver Co., Inc., 115 4th Ave., New York 3, N.Y.
Wickes Corp., U. S. Graphite Co. Div., Saginaw, Mich.
Wickwire Bros., Inc., 189 Main St., Cortland, N.Y.
Wilcox Forging Corp., Chestnut & Allen Sts., Mechanicsburg, Pa.
Wildberg Bros. Smelting & Refining Co., 742 Market St., San Francisco 2, Calif.
Wilde Drop Forge & Tool Co., Inc., 2938 Fairmount Ave., Kansas City 8, Mo.
Wilde Tool Co., Inc., 13th & Pottawatomie St., Hiawatha, Kan.
Wilder Mfg. Co., Inc., 1143 Terven Ave., Salinas, Calif.
Willamette Iron and Steel Co., 2800 NW Front Ave., Portland 10, Ore.
Williams, A.C. Co., Ravenna, Ohio
Williams, F.B. Co., 507 E Pershing Rd., Chicago, Ill.
Williams, J.H. & Co., 400 Vulcan St., Buffalo 7, N.Y.
Williams Gold Refining Co., Inc., 2978 Main St., Buffalo 14, N.Y.
Williams, H.E. Products Co., 106 S Main St., Carthage, Mo.
Williams, E.A. & Son, 325 Washington Ave., Carlstadt, N.J.
Williams-Bowman Rubber Co., 1949 S 54th Ave., Cicero 60, Ill.
Williamson Adhesives, Inc., 8220 Kimball Ave., Skokie, Ill.
Wilmington Fibre Specialty Co., New Castle, Del.
Wilson, H.A. Co., 2665 U. S. Route 22, Union, N.J.
Wilson Steel & Wire Co., 4840 S Western Ave., Chicago 9, Ill.
Wilson-Hurd Mfg. Co., Inc., Lines St., Wausau, Wis.
Winner Mfg. Co., Inc., P.O. Box 390, Trenton 3, N.J.
Winsorth Co., Inc., 43 Oak St., Delawanna, N.J.
Winters Foundry & Machine Co., Inc., 4123 Mahoning Rd., Canton 5, Ohio
Wire and Iron Products, Inc., 1725 16th St., Detroit 16, Mich.
Wirth, Carl & Son, Inc., 1625 Clinton Ave. N, Rochester 17, N.Y.
Wirz, A.H. Inc., 4th & Townsend Sts., Chester, Pa.
Wisconsin Aluminum Foundry Co., Inc., Manitowoc, Wis.
Wisconsin Centrifugal Foundry, Inc., 905 E St. Paul Ave., Waukesha, Wis.
Wisconsin Gasket & Mfg. Co., Granville, Wis.
Wisconsin Tool & Stamping Co., 9521 W Ainslie St., Schiller Park, Ill.
Witco Chemical Co., 75 E Wacker Dr., Chicago 1, Ill.
Witt Cornice Co., Galvanizing Div., 4454 Steel Pl., Cincinnati 9, Ohio
Wittman, Lawrence & Co., 40 Brooklyn Ave., Massapequa, N.Y.
Wollaston Foundry Corp., 24 Hollbrook Rd., Quincy 71, Mass.
Wood, John Co., 4435 S Western Ave., Chicago, Ill.
Wood, John Co., 509 Front Ave., St. Paul 3, Minn.
Wood Conversion Co., 1st National Bank Bldg., St. Paul 1, Minn.
Woodall Industries, Inc., 7655 E McNichols Rd., Detroit 34, Mich.
Woodruff & Edwards, Inc., 119 N State St., Elgin, Ill.
Woolf Aircraft & Products, Inc., 3441 Filbert St., Wayne, Mich.
Worcester Pressed Steel Co., 100 Barber Ave., Worcester 6, Mass.
Worcester Stamped Metal Co., 9 Hunt St., Worcester, Mass.
World Plastex, 1685 Boone Ave., New York 60, N.Y.
World Plastics, 1685 Boone Ave., New York 60, N.Y.
Worth Co., Briggs & Union St., Stevens Point, Wis.
Worthington Corp., 401 Worthington Ave., Harrison, N.J.
Wright, Albert, Screw Machine Products, 4032 Hollis St., Oakland 8, Calif.
Wright, G.F. Steel & Wire Co., 243 Stafford St., Worcester 3, Mass.
Wuest Bros., Inc., 924-936 W Hill St., Louisville 8, Ky.
Wyatt Metal & Boiler Works, Inc., P.O. Box 3032, Houston 1, Tex.
Wyatt's Plastics, Inc., 5928 Katy St., P.O. Box 3052, Houston 1, Tex.
Wycoff Steel Co., Box 1256, Pittsburgh 30, Pa.
Wyman-Gordon Co., 105 Madison St., Worcester 1, Mass.

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Xylos Rubber Co., 1300 Emerling Ave., Akron, Ohio

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Yale & Towne Mfg. Co., Powdered Metal Products Div., 9335 W. Belmont Ave., Franklin Park, Ill.
Yardley Plastics Co., 142 Parsons Ave., Columbus, Ohio
York Castings, Inc., 32 Latta Rd., Rochester 12, N.Y.
Young & Greenawalt, 5016 Hohman Ave., Hammond, Ind.
Youngstown Mfg., Inc., 66-76 S Prospect St., Youngstown, Ohio
Youngstown Sheet & Tube Co., Youngstown 1, Ohio
Fibercast Div., P.O. Box 727, Sand Springs, Okla.
Youngstown Welding & Engineering Co., 3800 Oakwood Ave., Youngstown 9, Ohio

z

Z & H Mfg. Co., 31 Welcher Ave., Peekskill, N.Y.
Zeller Corp., Ft. Wayne Rd., Defiance, Ohio
Zellner Foundry Co., 2088 Scranton Rd., Cleveland 13, Ohio
Zenith Foundry Co., (Ad p 362)
1501 S 83rd St., West Allis 14, Wis.
Zenith Plastics Co., 1600 W 135th St., Gardena, Calif.
Zirconium Corp. of America, 31501 Solon Rd., Solon, Ohio
Ziv Steel & Wire Co., 2945 W Harrison St., Chicago 12, Ill.
Zolatone Process, Inc., 3411 E 15th St., Los Angeles 23, Calif.
Zophar Mills, Inc., 112 26th St., Brooklyn 32, N.Y

In contacting suppliers, please mention the Materials Selector